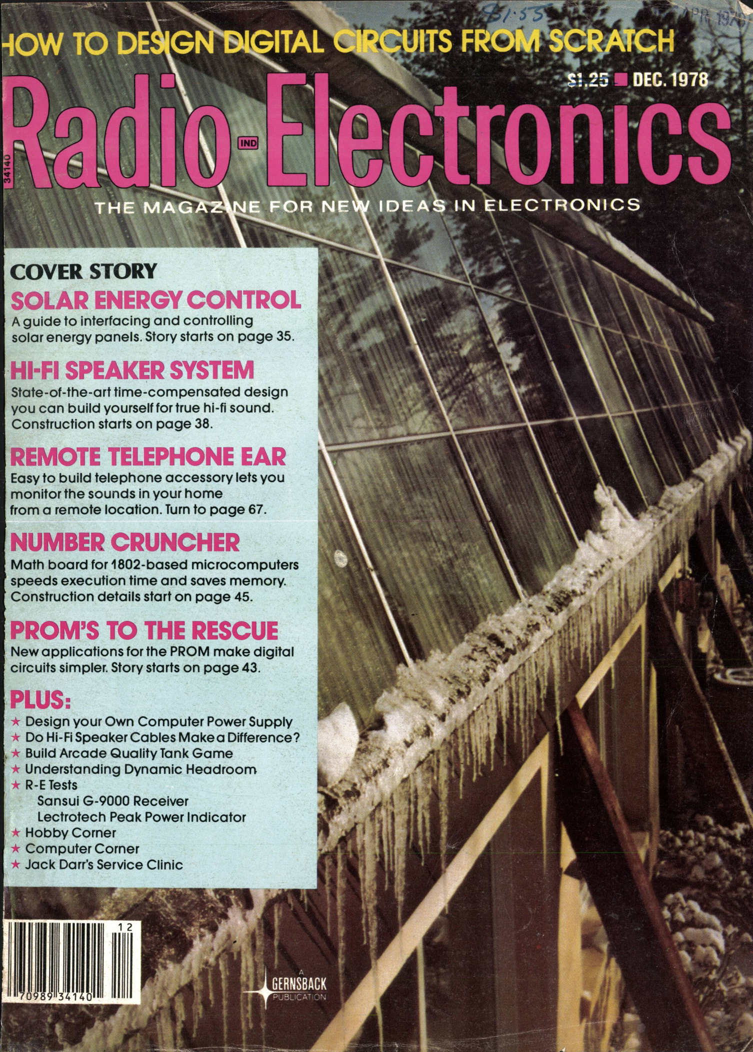

HOW TO DESIGN DIGITAL CIRCUITS FROM SCRATCH

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Radio-Electronics

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THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

COVER STORY

SOLAR ENERGY CONTROL

A guide to interfacing and controlling solar energy panels. Story starts on page 35.

HI-FI SPEAKER SYSTEM

State-of-the-art time-compensated design you can build yourself for true hi-fi sound. Construction starts on page 38.

REMOTE TELEPHONE EAR

Easy to build telephone accessory lets you monitor the sounds in your home from a remote location. Turn to page 67.

NUMBER CRUNCHER

Math board for 1802-based microcomputers speeds execution time and saves memory. Construction details start on page 45.

PROM'S TO THE RESCUE

New applications for the PROM make digital circuits simpler. Story starts on page 43.

PLUS:

- ★ Design your Own Computer Power Supply
- ★ Do Hi-Fi Speaker Cables Make a Difference?
- ★ Build Arcade Quality Tank Game
- ★ Understanding Dynamic Headroom
- ★ R-E Tests
  - Sansui G-9000 Receiver
  - Lectrotech Peak Power Indicator
- ★ Hobby Corner
- ★ Computer Corner
- ★ Jack Darr's Service Clinic

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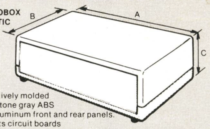
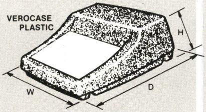
VEROBOX PLASTIC



Attractively molded in two-tone gray ABS with aluminum front and rear panels. Accepts circuit boards horizontally or vertically.

ORDER CODE	A	B	C	PRICE
75-1238D	154	85	60	$6.82
75-3008J	180	120	65	$8.90
75-1411D	205	140	75	$9.02

VEROCASE PLASTIC

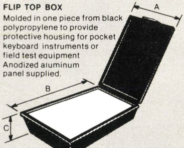


Vacuum formed from textured black ABS. Designed for instruments incorporating a keyboard and display. Anodized aluminum panel supplied for component mounting.

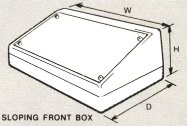
ORDER CODE	WIDTH	DEPTH	HEIGHT	PRICE
75-1800J	220	276	100	$25.70
75-3960E	550	340	120	$50.31

FLIP TOP BOX

Molded in one piece from black polypropylene to provide protective housing for pocket keyboard instruments or field test equipment. Anodized aluminum panel supplied.



ORDER CODE	A	B	C	PRICE
75-3018C	75	130	22	$5.76
75-3019J	127	196	32	$7.50



SLOPING FRONT BOX

Sloping front boxes. Two-tone gray with aluminum front panel. Provisions in base for circuit board or plate mounting.

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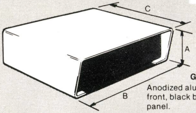
75-1798K	171	121	75	$10.94
65-2523E	220	156	100	$11.74



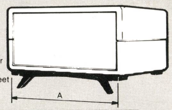
G SERIES CASES

Anodized aluminum cover with visor front, black base, front and rear panel.

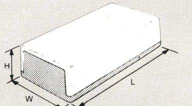
ORDER CODE	A	B	C	PRICE
91-2672A	44,0	134,0	123,0	$12.07
91-2673G	64,0	224,0	176,5	$18.32

TILT LEG ASSEMBLY FOR PLASTIC VEROBOX

A kit containing a tilt leg and four molded feet with rubber inserts which replace the existing box feet and raise the front panel to a convenient viewing angle.

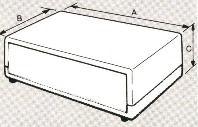


ORDER CODE	A	COMPATIBLE VEROBOX	PRICE
75-1493A	144	75-1238D	$2.39
85-1494G	170	75-3008J	2.45
75-1492F	193	75-1411D	2.48



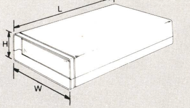
Two-tone gray boxes molded in high impact polystyrene. Lower section provided with threaded inserts for mounting components or circuit boards.

ORDER CODE	WIDTH	LENGTH	HEIGHT	PRICE
65-2514F	50	100	25	$3.25
65-2518H	65	120	40	4.09
65-2520J	80	150	50	4.68



New additions to the series of two-tone gray ABS boxes with aluminum front and rear panels.

ORDER CODE	A	B	C	PRICE
75-2682L	125	65	30	$5.24
75-2683F	125	65	40	6.08
75-2684A	125	65	50	6.79



Attractive light gray boxes of high impact polystyrene come complete with anodized aluminum front panel and molded-in compartment for standard 9V. battery.

ORDER CODE	WIDTH	LENGTH	HEIGHT	PRICE
65-2036H	68	110	33	$5.78
65-2068B	92	155	45	8.90
65-2073K	138	190	68	12.09

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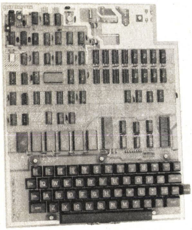

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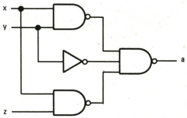
DECEMBER 1978 Vol. 49 No. 12

SEASON'S GREETINGS

The editors and staff of Radio-Electronics join in sending holiday greetings and our best wishes for a happy new year



$a = xy + xz + y$

DESIGNING DIGITAL CIRCUITS from scratch. The step-by-step approach starts on page 63.

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looking ahead

TV and hi-fi: Important developments are in the wind in the field of TV sound—a chain of events set in motion by the very limited use of satellites for domestic networking and followed by the telephone company's conversion of its intercity relay systems to diplexed sound (**Radio-Electronics**, July, 1978). Both relay systems now accommodate sound channels capable of a frequency response up to 15 kHz, compared with 5 kHz under AT&T's old system of transmitting TV sound by separate telephone line. Since last January, most network broadcasting (except for an occasional 16-mm movie) has been accompanied by noticeably better sound. But that's not all—AT&T's network lines now are capable of handling two discrete multiplexed sound channels, each with a frequency response out to 15 kHz.

This two-channel sound will be available with the TV signal as soon as a rate schedule is worked out by AT&T and approved by the FCC. There are no stereo TV sets, of course, and TV stations aren't allowed to transmit stereo sound signals—even if they were equipped to do so—so the first use of two-channel sound is likely to be for the simulcast FM-station sound accompanying TV music broadcasts. The diplexed signal along with the TV picture eliminates the complicated synchronizing and phasing processes that are needed when the stereo sound is networked separately from the picture, as traditional in network stereo simulcasts.

So now we have an interesting situation: Most TV broadcasting is accompanied by true hi-fi sound, but virtually no TV receivers are capable of passing it on to viewers. Network television is capable of transmitting stereo or other types of dual-sound signals, but stations aren't permitted to broadcast with dual sound. However, there are signs that this impasse will be broken. Most TV set manufacturers are now working on improved sound systems to take advantage of the better vibes coming from the stations. Don't expect hi-fi perfection, but starting with next spring's lines of sets, some models will offer wider frequency response, higher-powered amplifiers, bigger speakers and better baffling.

For those who can't wait for better TV sets to provide higher-quality sound, there will be a growing number of hi-fi video tuners and receivers, such as those now being developed by Pioneer and Wintec, both in direct response to the better sound offered by stations.

Will the next step be stereo sound? The whole subject is highly controversial, and many broadcasters, as well as some TV set manufacturers, will tell you at the drop of a decibel that stereo isn't suitable for TV—there's not enough music being broadcast, the picture is too small, and so forth. But there are exceptions in both ranks. Projection TV manufacturers are gung ho for stereo sound; as is the Public Broadcasting Service, whose associated stations originate many musical programs. Sylvania also hopes to take leadership among set manufacturers in pushing for stereo.

Even if broadcasters and manufacturers collectively don't want stereo, this doesn't mean they're against two-channel sound. Many approve of a system that was used in Japan in 1970 (and about to be revived there). This system provides two completely discrete channels, and can be used for language translations, stereo or any other application in which two sound tracks can be used. The broadcasters—led by ABC-TV—see the dual-sound track concept as a winner in bilingual areas such as New York, southern California and Miami, where viewership is low among those whose primary language isn't English. Manufacturers certainly wouldn't mind producing TV sets with special circuitry for selecting sound Channel A, Channel B or stereo.

The next step is expected to be the formation of an industry committee to develop and test various two-track proposals before any proceeding by the FCC. It could take from three to five years before definitive standards are set for stereo and other dual-sound TV broadcasts but they do finally seem to be on the way. And the pressure for stereo won't be lessened in any way when videodiscs come on the market. Many of these discs will have stereo sound, and all videodisc recorders will have jacks for stereo inputs.

New VCR's: Home videocassette recorders are proliferating, with new, more versatile step-up units reaching the market this fall. Perhaps the most fascinating is a programmable unit made by Matsushita Electric and being marketed in two slightly different versions under the Magnavox and RCA brandnames, with other similar units to come. The new VCR takes maximum advantage of the four-hour-per-cassette recording mode of the VHS format. Using a built-in microprocessor, a fluorescent digital display and a 14-pushbutton varactor tuner, the new VCR may be programmed up to one week in advance to record four different shows, automatically turning on and off and switching channels. An optional mode of programming permits the recording of the same show every day of the week.

An interesting feature of the programmable VCR is "electronic indexing." A special electronic cue is placed on the tape at the start of each recording, whether the machine is in the manual or the programmed mode. The beginning of any program then may be located automatically by pushing the fast-forward button.

New VCR's in the Beta and VHS formats have been introduced for outdoor recording. The Sony and JVC units each weighs about 20 pounds. A rechargeable battery will operate the VCR and its associated color camera for one hour on a charge. Accessory tuners and timers are available for recording TV programs off the air.

A new VHS-format recorder by JVC lets you double your television viewing without increasing the amount of time you watch—that is, if you don't mind speeded-up action. A special remote-control switch plays tapes at double speed. Digital encoding keeps the sound at the proper pitch and comprehensible. The same unit provides a freeze-frame picture when the pause button is pressed. A new Hitachi VHS recorder also has the freeze-frame feature. With a new recording head, Hitachi claims a picture signal-to-noise ratio of 46 dB, which it says is the best of any home VCR.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

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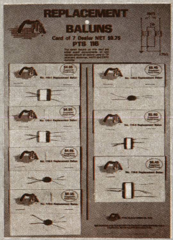

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new & timely

Quartz analog watches tells time with "electronic hands"

Texas Instruments' completely electronic *Time Indicator* watch is an antimagnetic, shock-resistant LCD quartz analog watch that tells time without any moving parts, using "electronic hands." TI believes this design may provide the answer for those who want a watch without gears or other moving parts to wear out, yet need to see a visual time relationship.

TEXAS INSTRUMENTS new *Time Indicator* watches combine the advantages of both mechanical and digital watches.

The liquid crystal display that sweeps the face of the watch (in similar fashion to mechanical hands) is driven by an IC. Several timekeeping modes are available: hours/minutes; minutes/seconds; hours/minutes in another time zone; plus day and date; and a stopwatch gives the elapsed time in hours/minutes, minutes/seconds and seconds/10ths of seconds.

The watch is powered by a lithium-manganese dioxide battery and comes in two styles: round, in either white-gold or yellow-gold tone metal or square in either stainless steel or gold-tone metal; the strap can either be of leather or matching metal clasp bracelet. The watches range in price from $275 to $325.

50 Radio Shack Computer Centers to open in 1978-1979

Lewis Kornfeld, president of Tandy Corporation's Radio Shack Division, has announced that 50 new computer sales and service stores will open in 1978-1979; the new ventures will be called Radio Shack Computer Centers.

Although some of the Computer Centers will be located in new or existing Radio Shack stores, most will be separate operations in major market areas. According to Mr. Kornfeld, "their purpose will be to assist area Radio Shack stores in answering computer questions, closing sales and developing quantity sales (particularly of Radio Shack's TRS-80 system), and peripheral systems to businesses and institutions."

The Centers will provide classroom areas to teach computer use and programming to customers. In addition to servicing Radio Shack computer products, the Centers will sell a variety of components, software and some hardware of brands other than the TRS-80 system.

Video inventions use liquid-crystal switches

Two new inventions use liquid-crystal optical transmission switches that can help reduce the size, price and power requirements of video cameras, screens and projectors.

The "Flying Hole Video Camera" and "Flying Hole Display and Projector" use a two-dimensional array of liquid-crystal switches operated so that all but one are opaque. This "hole" is moved around in a scanning pattern.

In the camera, the light that is transmitted through the hole is converted to electrical signals by a photo detector or color-sensitive photo detectors. In the projector and display, the light is projected through the hole by a light source or a group of color-sensitive light sources. Since the video projector/display does not require a cathode-ray tube, it is small and flat enough to be either wall-mounted or worn on the wrist. The inventions were announced by an independent Canadian inventor, Donald L. Orr.

Wrist device prints messages, aids handicapped

Canon, U.S.A., a subsidiary of Canon, Inc., Tokyo, has developed a small battery-operated wrist device that prints messages on paper tape designed to provide fast communications for persons suffering from a variety of verbal or motor disabilities.

WRIST DEVICE, the *Communicator*, keyboard contains 26 letters, and shift, back and space keys to print messages at a 10 character-per-second speed. The device is a special fast communication aid for nonverbal, deaf and other handicapped persons.

The device called the *Communicator* is distributed by Telesensory Systems, Inc., 3408 Hillside Avenue, Palo Alto, CA 94304. It is as small as a pocket dictionary, weighs 11 ounces and can also be worn around the neck. Messages are printed on paper tape at a speed of 10 characters-per-second, with a tape storage capacity of 12,500 characters. The keyboard contains 26 alphabetical letters arranged according to frequency of use, plus it contains shift, back and space keys. Pressing the shift pushbutton allows numbers and symbols to be used, and vowels and consonants are differentiated by color. The *Communicator* sells for $549.

Computerized information system is developed for Canadian TV viewers

Three Canadian firms, Bell Canada, Southam Press, Ltd., and Torstar Corporation have agreed to cosponsor a pilot demonstration of a data system that will provide information stored at a central computer and transmitted via telephone lines to TV viewers whose sets are connected to the computer center.

The data system (known generically as videotex) consists of a computer connected to a single TV set with an attached keyboard. Using the keyboard a viewer can retrieve preprogrammed data, which is then displayed on the screen either as words or graphically. A Bell Canada spokesman said that this pilot demonstration will be followed by a more extensive market study later in 1980, in which the computer will be connected to several home TV terminals. Suggested future applications for the system are in providing weather news, travel data, general news programs, entertainment and even some advertising.

NESDA/ISCET choose officers and distribute awards at 1978 NESC

Approximately 600 persons attended the August 1978 National Electronics Service Convention (NESC) in Portland, OR. Among the many scheduled events, including a trade show, seminars and many social functions, were both the NESDA and ISCET conventions.

The ISCET and NESDA agenda included the election of officers for 1978–1979, as follows:

For NESDA—president, Robert A. Vilont; vice president, Warren Baker; secretary, West Correll; treasurer, George Simpson; and regional officers Ted Stackhouse, Dorothy Cicchetti, Joe Gately, Billy Williams, Art Nelson, Bill Abernathy, Keith Knos, Jack Kelly, Bill Lawler, and Dick Scott.

For ISCET—president, Jesse Leach (also serving ex-officio on the NESDA executive committee and council); vice chairman,

continued on page 12

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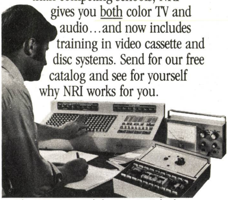

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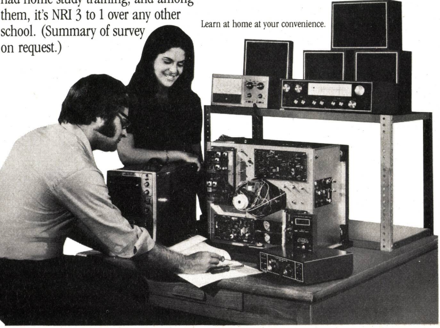


Learn at home at your convenience.

continued from page 6

Forest Belt; secretary, Leon Howland; and treasurer, George Sopocko.

Those present at the ISCET convention voted unanimously to return ISCET headquarters to NESDA facilities in Indianapolis. A Joint Internal Affairs Committee was appointed by ISCET and NESDA presidents to study and consider the question of ISCET/NESDA autonomy. A report, incorporating the results of an opinion survey taken among the respective bodies, will be presented at a joint ISCET/NESDA membership meeting in 1979. The committee is composed of ISCET members Herschel B. Lawhorn, Dorman L. McDonald and Larry Steckler (chairman), and NESDA members Warren Baker, Jack Kelly and Dick Scott.

Among other scheduled events was a NESDA awards banquet at which LeRoy Ragsdale, outgoing president, received both the "Man of the Year" award and the "NESDA Outstanding Officer" award. Other winners were Don Surrette, Leo Cloutier, Nolan Boone, Fred Schuneman, Warren Baker, Gene Dillingham, Ray McAllister, Keith Knos, and Morris Finneburgh, Sr.

Another NESC highlight was the induction into the Electronics Hall of Fame of two new members: Enos Rice (CES/CET) and (posthumously) the late Ralph Johonnot. Mr. Rice, who is 74 years old, was honored for his 44½ years in the service industry and for his long involvement in and support of NESC activities. The late Mr. Johonnot was cited for his long career in the service industry; for his many years as an officer with the California State Electronics Association; and for his part in the inception of the CET program and the Western States Conference.

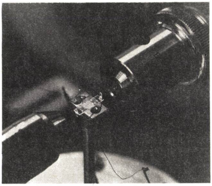
The 1979 NESC will be held in Tucson, AZ, concurrently with the Arizona State Electronics Association Convention.

Integrated optical device has multiple applications

A small integrated optical device that can have multiple applications has been developed by Bell Labs. It can be used as a logic element in optical memories; a pulse shaper and limiter; an optical switch; a difference amplifier; and as an "optical triode."

Operating at extremely low power levels over a wide range of wavelengths, the device is an optical waveguide version of a nonlinear Fabry-Perot resonator whose nonlinear characteristics are produced by using a photodetector output to drive the resonator's electro-optical elements. Other features include acceptance of electrical or optical outputs; its nonlinearity can be modified using a nonlinear circuit; acceptance of multiple logic inputs; and multilevel operation.

The device is processed using standard IC techniques by diffusing titanium ions onto an electro-optic lithium-niobate substrate. Incoming light rays are reflected back and forth between dielectric mirrors affixed to the cleaved ends of the substrate material. A beam splitter transmits a portion of this light to the detector whose output is used to create an electric field between the electrodes on the crystal that modulates the refractive index of the crystal and produces the nonlinear characteristics.



BELL LABS integrated optical device is Fabry-Perot resonator formed by dielectric mirrors on the ends of the electro-optic lithium-niobate substrate material.

In multilevel operation or A/D conversion, a high gain is required in the feedback loop, providing as many as 15 transmission levels. With less feedback and the resonator tuned for transmission showing a hysteresis characteristic, the device functions as a memory element. When operated in a high-transmission state, its constant power output lets it operate as an optical limiter. In the "optical triode" mode, when the resonator is tuned to transmit an S-shaped waveform, power transmitted through the waveguide changes rapidly according to the output. A small degree of light at the detector produces a vast change in transmitted light; a weak light signal falling on the detector controls the transmission of a power light beam on the device.

Morizono, Leonard, Staes win SMPTE awards

The Society of Motion Picture and Television Engineers (SMPTE) awarded the 1978 David Sarnoff Gold Medal to Masahiko Morizono of Sony Corporation. Mr. Morizono, general manager of Sony's Video Products Division, was cited for his leadership and outstanding engineering accomplishments in developing TV electronic news gathering (ENG) equipment. Mr. Morizono's other achievements include the development of portable helical-scan VTR systems exhibiting high-calibre editing capabilities; plus the design and development of audio and instrumentation recorders, U-matic cassette recorders, time-base correctors, cameras and accessories.

SMPTE also presented its 1978 Journal award to Eugene Leonard, Da Vinci Systems Group, with honorable mention to K. Staes, Agfa-Gevaert N.V., for their paper published in the October and August 1977 SMPTE *Journal*, respectively.

The award was presented at the Society's annual Awards Presentation in October, 1978, at the Americana Hotel, New York City.

Zenith releases three-hour VCR, color cameras, tape

A three-hour video cassette recorder, two color cameras and a three-hour-format cassette tape are all part of Zenith Radio Corporation's new fall line.

The *model KR9000W* is a single-speed VCR that can record up to three hours of programming using Zenith's three-hour tape. The remote PAUSE switch lets you stop the tape in either playback or record modes, so that you can edit during recording or stop playback if you must leave the room. Other controls include a six-push-button keyboard, a clock/timer, UHF/VHF tuners, automatic fine tuning control, and a special tracking feature to handle variations in prerecorded tapes.

THREE-HOUR VIDEO CASSETTE RECORDER (*model KR9000W*) released by Zenith is a single-speed unit with built-in UHF/VHF tuners; timer; standard pushbutton controls; tracking switch; remote PAUSE control; and tape counter with memory.

The two color cameras for use with the VCR (*models KC1000* and *KC1250*) offer a number of significant features: the *model KC1000* has a pop-up viewfinder that matches the view angle of the 25-mm-long barrel lens designed to be used with a tri-electrode vidicon tube; a built-in mike; a remote PAUSE switch; plus adjustable temperature and brightness controls and an automatic light-level switch. The *model KC1250* (which incorporates all the features of the *model KC1000* color camera) also has a 6:1 Canon zoom lens incorporating a viewfinder with a 1½-inch black-and-white monitor screen. Suggested retail price range: \$2095—\$1395. **R-E**

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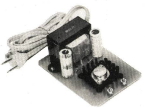

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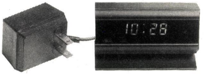

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- ★ Uses MM5314 clock chip
- ★ Switches for hours, minutes and hold functions
- ★ Hours easily viewable to 20 feet
- ★ Simulated walnut case
- ★ 115 VAC operation
- ★ 12 or 24 hour operation
- ★ Includes all components, case and wall transformer
- ★ Size: 6-3/4" x 3-1/8" x 1-3/4"

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CIRCLE 15 ON FREE INFORMATION CARD

editorial

Radar Speed Traps, Detectors and Countermeasures

Technology is a wonderful thing. It starts off by doing a job. We can use radar to identify speeders on the highways . . . those people who endanger the lives of others using American highways. It can also help increase the monies received by a municipality in traffic fines. And it's been with us for a long time now.

Recently, electronic countermeasures have become available to the public in the form of detectors that warn you when you near a radar trap. Government agencies have fought these devices in several ways—made them illegal in some states, used portable units, different frequencies. Here's the latest development . . . police departments are buying miniature low-power radar transmitters to sprinkle along the sides of the road to trigger those radar detectors. Maybe they hope that after you've run through three or four false alarms you'll ignore the real radar and contribute some dollars to the local budget. By the way, those transmitters are frequently made by the same people who make your radar detector.

Then comes the latest countermeasure, a nifty little radar transmitter for the motorist. According to the outfit offering it, you simply dial in the speed you want the radar trap to clock you at. Your transmitter then issues a signal that tells the police you're only going 30 MPH or whatever you select. We're deliberately not listing the name or address of the manufacturer since we don't think such a device is legal under FCC rules. Please don't write us for that information because we won't respond. But what we would like to know is what you think of such devices and can you dream up any that are even better.

Electronic countermeasures aren't new, but what a funny world it is when so many dollars are being spent in a battle with the traffic laws. Maybe some serious thought to raising the speed limits to a reasonable level would make more sense.

Larry Steckler

LARRY STECKLER
Editor

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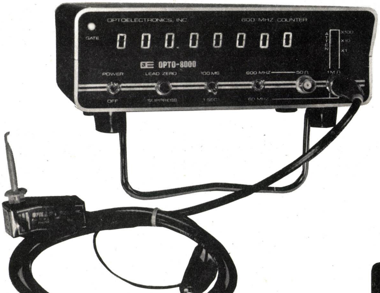

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CIRCLE 21 ON FREE INFORMATION CARD

letters

WHAT IS AN ELECTRONIC ENGINEER?

As an engineer and head of a growing organization, I often meet people who don't really know what an electronic engineer does. All too often these people visualize an engineer as "someone who sits in a cave and designs things." Nothing could be farther from the truth, and I'd like to dispel this myth.

As I see it, the electronic engineer has the job of creating new electronic equipment or devices using the latest technology and to be manufactured at the lowest cost. In short, his job is to make money for the company that employs him. Besides circuit design, you'll find the engineer assisting in all areas from design to final product. And he will often be there when the design is being upgraded!

To be more specific, a typical engineer can spend as little as 10% of his time on actual circuit design. (This depends on the project, of course!) The rest of his time is spent assisting draftsmen in circuit-board layout, assisting in package design, writing specifications for the product, selecting components and materials for the production models—not to mention the building of the prototypes!

After the device is built on the production line, there are process-control problems to resolve, quality-control problems and more. Ever see 20,000 pieces of equipment roll off a production line—defective? This same engineer may step in and solve the problem—saving the company money. This is engineering in its finest hour, and an important distinction. You'll find most engineers in industry doing at least most of these things, and often much more. The engineer is rewarded with a sense of accomplishment, a modest salary and, if he's good, a chance at getting a management level job.

Now that you know what an engineer does, let's look at working with IC's. Actually, working with IC building blocks on paper isn't too hard. The computer fans do this often, as can anyone with the IC handbook. I believe this sort of work should be called *designing*. It is different from *engineering* because the designer generally does not become involved with all the areas mentioned previously; at least this has been true of the "designers" I know. Also, an engineer designs a circuit by either selecting components known to best fit the job from past experience, or by using components of the latest design. This process requires an extensive knowledge of electronic circuitry, electronic components, plus manufacturing processes. All this expertise is necessary to build a project easily at the lowest cost . . . and cost is the name of the game in electronics today. None of the designers I know have the knowledge to optimize their circuitry. Also an extensive knowledge of electronics is important when the production line shuts down—an engineer would know how to start it up, a designer might not. And that's what sepa-

rates the designers from the engineers—*knowledge and experience!*

If there are any doubters among the designers, let's see them design an 8-bit A/D converter for under $5. It's been done—but not by designers. Cost is the reason; an IC block approach costs too much.

To sum up, I propose that the people who string IC's together should be called "designers," and people who do the same but have extensive knowledge about their product should be called "engineers."
GARY McCLELLAN

S-100 BUS COMPANIES

I recently received from you a list of companies dealing with the S-100 bus.

I was somewhat surprised to see that the list was only two pages long. And it didn't even include the manufacturers of the equipment I have running in my system. Therefore, I decided to do a bit of research on a small scale. I looked through just the February 1978 issue of *Interface Age* and the February 1978 issue of *Kilobaud*, and the only company I knew about that I couldn't find was PolyMorphic Systems, the manufacturer of my computer.

Therefore, I am including a list of the companies I found less the ones on your list, plus phone numbers. I've listed them in the order I found them:

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16611 111th St. S.E.
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Alpha MicroSystems
17875 Skypark North
Irvine, CA 92714
(714) 957-1404

Space Byte Systems Group
1720 Pontius Ave., Suite 201
Los Angeles, CA 90025
(213) 468-8080

Paratronics, Inc.
800 Charcot Ave.
San Jose, CA 95131
(408) 263-2252

MECA
7026 O.W.S. Rd.
Yucca Valley, CA 92284
(714) 365-7686

Info 2000 Corporation
20630 South Leapwood Ave.
Carson, CA 90746
(213) 532-1702

Trace Electronics, Inc.
P.O. Box 3247
Hampden Station
Reading, PA 19604
(215) 779-3677

Forethought Products
P.O. Box 386-E
Coburg, OR 97401
(503) 485-8575

Wameco, Inc.
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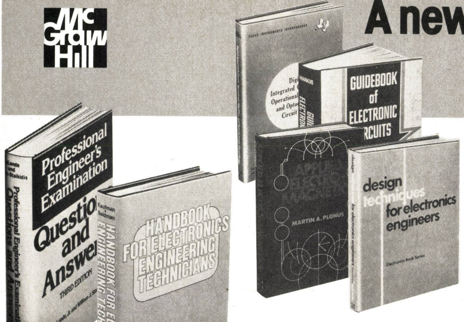
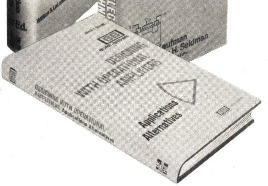
continued on page 22

A new introductory Electronics





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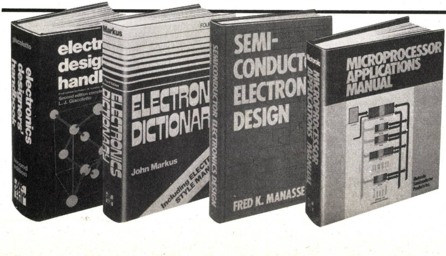

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I realize this list isn't quite complete, but I thought you should update your list. I would like to add that Vandenberg Data Products has the only 16K RAM board available for the S-100 bus for $330, fully static (kit) and rated at 250 μs, quite suitable for a Z-80. Anybody else's static RAM costs roughly double that. I am currently running 32K of their memory and am thinking hard about another 16K. All components in my system (except the TV) were built from kits.
MARCUS S. LEWIS
Omaha, NE

S-100 BUS ADDITIONS

I enjoyed the S-100 article (April 1978 issue, page 48) and S-100 bus listing. In the listing you asked to be informed of other S-100 products not listed.

CGRS Microtech manufactures three boards for the S-100:

1. The 6502 MPU Board—to our knowledge, this is the only S-100/6502 board for the S-100. It has been in production for 18 months and is working very well.
2. The T.I.M. II I/O Board—this is a "system monitor board" that provides ROM, RAM, and parallel and serial I/O ports.
3. The Multi-I/O Board—provides I/O for the Persci 1070 floppy-disc controller card as well as 4K of ROM, two parallel ports and two serial ports.

WILLIAM M. GOBLE
CGRS Microtech
P.O. Box 368
Southampton, PA
(215) 757-0284

WHERE ARE THE ELECTRONIC DESIGNERS?

I wish to respond to your June 1978 editorial entitled "Where Have All The Designers Gone?"

Electronic designers have always been wiring up "black boxes" to form new devices. What are resistors, transistors, capacitors, inductors, transformers, etc., but "black boxes"? A black box is simply a device with known characteristics.

The designer today uses IC's to reduce the amount of drudgery and cost in his designs. How would you like to redesign the NAND gate hundreds of times for each digital project? If every general-purpose IC (i.e., gates, op-amps, latches, etc.) had to be built from discrete components, a digital clock, stereo, CB radio and any other electronic device would cost much more than it now does.

In answer to the question, "What does an electronic designer do?" I think I am qualified to respond since I am an electronics engineer with IBM. My job is to design, oversee construction and debug electronic circuits. It also requires taking sometimes as many as 100 separate inputs and creating the proper responses at the proper time. I use digital IC's to create these circuits and do consider each circuit to be a new one.

This *is* designing, just as engineers in the 1950's designed using only transistors, tubes and other less-complicated devices.

I don't think it has slowed either the development or development time of new devices; it has simply made it economically
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LETTERS

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feasible to develop more complicated products. For example, with IBM's Series III copier (yes, I know I'm biased), would so many functions have been possible without IC's? I think not.

Finally, an electronic designer is someone who extracts information from electrical signals (inputs) with electronic components, and who controls (via outputs) other devices with that information. The process of creating the device between the inputs and outputs (which, by the way, are usually defined before the design is begun) is electronic design.

DENNIS A. ROWE
Boulder, CO

With respect to your June 1978 editorial, I think that persons who use and apply integrated circuits are, indeed, designers. They may be using available devices to design something that is totally new, unique, and perhaps useful, too. I think that the IC has freed us to concentrate upon the task at hand without having to craft the tools that are necessary to accomplish it. Remember the days of the tube-based op-amp, the tube-based counters and flip-flops, etc.? They are gone, luckily.

If IC users aren't really designers, then neither are the solid-state physicists and semiconductor engineers, since all they are doing is moving around the same atoms in different ways. The silicon, gallium and arsenic remain the same . . . the designers just do different things with them.

JONATHAN TITUS

In reply to your June editorial, I feel that the designer is still with us.

It seems to me that the designer's role has taken three different paths—on one path he devises all the IC's we use. On another path, he is a systems designer, responsible for the design of the complete complex system. And the third path is that of designing the new instrumentation used to service complex devices.

Today, the engineer can take the IC's and connect them together to make a circuit or simple electronic device.

I really don't envy the job of the instrumentation designer for he has to design instruments that are to be used repeatedly by people not in the electronics field. For example, automotive mechanics are finding more and more electronics in our modern cars. They cannot just exchange one module for another; because of increasing complexity, they must use instruments to troubleshoot the entire system to find the malfunction.

Twenty years ago, when I graduated from electronics school, we did not have very many test instruments. We could troubleshoot and repair just about everything electronic with an OS-8 oscilloscope, TS-352 VOM, TV-7 tube tester and BC-221 frequency meter.

I would hate to troubleshoot and repair some of today's complex electronics systems with those Stone Age instruments. If you look at some modern instrumentation, you can see the designer has been busy. And there is always something new being released to make our jobs easier.

I feel that economics, not the integrated circuit, has slowed down the development of new electronic devices. The question is now when a new product is developed, is it to be made inexpensive enough to be disposable when it malfunctions or is it to be made repairable? And who will repair it? There are a few products on the market that are disposable because of their low cost—radios, LED watches and calculators. But now I feel that many manufacturers are taking a wait-and-see attitude before producing any more low-cost products.

JERRY W. CLARK
New Richmond, IN

HOME COMPUTERS

I have a hobby computer. I have not yet and probably never will wire it up to "run the house." Most household applications can be controlled just fine with a motor and cam for several operations per day. If I did "control the house" with my computer, I couldn't experiment with new programs since I might erase the household program.

What I really do with my computer is write game programs. After spending many hours writing and debugging the program, I

play the game a couple of times and start writing a new program.

I agree with you that the "Home Computer" is nonsense. The only application I might have for it is to balance my checkbook. Even then I would pull out my pocket calculator.

Many people ask, "Well then, what good is your computer?" I guess the best answer is, "What good is your home TV set?"
E. MORRIS
Midland, MI

I do not own a hobby computer. I do have three hi-fi sets, a VCR, model railroad, darkroom and studio to support; so when I received several estimates of the cost of a computer system ($8000) with enough memory and "crunch" to cross-reference my collection of 1000 LP records and songs into several categories, I bailed out.

I do know about computers since we use one to roll our film and tapes at the TV studio I work at. I also can remember anytime, anyplace that next month the real estate tax is due. I know how much I have in several savings and checking accounts. I don't need an expensive computer to remind me (if I happen to be near it), but if the price were $200 for the system described above with a cassette, easily interchangeable programs, a video (or TV) monitor or hardcopy at additional cost, I might buy it.

I guess what I mean is I don't like to "play games" just for the sake of playing games, and if it takes possibly more time to program the computer to do a job than it might take to do the job the usual way, why bother? But if the cost of computers drops as it did with small calculators, we will have a different ball game.
DICK WARTENBERG
Brooklyn, NY

DARKROOM TIMER

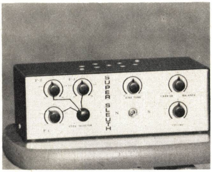
With respect to my article in the July and August 1978 issues ("Build A Digital Timer for Your Darkroom"), the accuracy of the schematic was excellent. However, there were six errors that must be noted:

1. In the table shown in Fig. 3 that lists the power and ground connections for the IC's, I wrongly listed pins 14 and 7 as power and ground for IC13. The correct pins are 16 for power and 8 for ground.
2. In Fig. 3 again, an LED is missing between pins 10 and 1 of DIS4, but this is an internal LED contained within DIS4 as are the others.
3. The point at which S4 connects to the main PC board should be labeled "D."
4. The Parts List did not have numbers for the transistors. They can be any NPN silicon transistors whose beta is between 50 and 150, such as 2N2222, 2N957, etc.
5. The part number given for S1–S3 is incompatible with the PC board/front panel combination. The correct UID Electronics part numbers are: S1: RSW-0622-SD-BB-S-B1-BK; S2 and S3: RSW-0022-SD-BB-S-B1-BK.
6. One of the key cap part numbers should be 42-3100-03, not 40-3100-03. The "42" indicates double-width, which is what the "0" key cap is.

RAYMOND G. KOSTANTY **R-E**

equipment reports

Super Sleuth Descrambler



CIRCLE 118 ON FREE INFORMATION CARD

AS MORE AND MORE LAW-ENFORCEMENT CHANNELS are being monitored by unauthorized listeners using scanners, many agencies have attempted to improve voice security by using "scramblers." A scrambler is an audio frequency inverter. High frequencies become low and low frequencies, high; the result is unintelligible.

The *Super Sleuth* descrambler is designed to reinvert audio signals to normal. It plugs into the external speaker jack of a scanner and is usually left switched to the normal mode. When conventional transmissions are received, the descrambler's internal speaker is connected directly to the scanner's speaker jack, and the descrambler circuitry is off. When a scrambled message is received, the *Super Sleuth* is switched to the scrambled mode, and an internal ring-demodulator circuit rearranges the inverted speech to normal speech.

The *Super Sleuth* is entirely self-contained, including eight internal AA batteries (not provided), and its three adjustable decoding controls are switch-selectable.

Many law-enforcement agencies use more than one audio code, switching codes at different times; the three switch-selectable controls allows the listener to individually adjust each control to correspond to a given code, and then leave it set so that rapid switch-selectable decoding of the scrambled message is possible the next time it is encountered.

A FINE TUNE control allows an occasional adjustment of the audio for natural voice quality (however, it is seldom needed).

Since descramblers (and scramblers) inject an audio signal into their circuitry, that signal should be removed from the resultant audio output so that it doesn't cause annoying interference. The *Super Sleuth* has a CARRIER/BALANCE null control knob to accomplish this.

Finally, the volume control permits you to adjust the audio output to a comfortable listening level.

The *Super Sleuth* looks impressive, functions well and its audio quality is very natural. Although the top-mounted internal speaker would be inconvenient for under-dash mobile mounting, most listeners would probably use the unit next to a scanner in the home or office.

A 741 op-amp audio oscillator injects an

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EQUIPMENT REPORTS

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adjustable tone into a diode-bridge ring modulator (mixer), where it heterodynes with the inverted audio from the scanner's speaker-jack output. The difference frequency (in this case, normal unscrambled speech) is fed to an LM38ON amplifier IC for up to two-watts audio output.

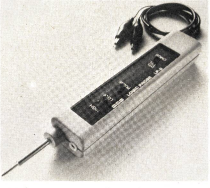
The *Super Sleuth* weighs only 2 lb. and measures 10 W × 3½ H × 5 inches D. Its power drain is 12 VDC at 25 to 300 mA depending upon audio-output level. The unit is available for $79.95 from Krystal Kits, Box 445, Bentonville, AR 72712. **R-E**

Continental Specialties LP-2 and DP-2 Logic Probes

ALTHOUGH USING AN OSCILLOSCOPE AND EXpensive logic analyzers to solve knotty troubleshooting problems is really best, logic probes save time in most situations. Using very few controls, the *models LP-2* and *DP-1* probes manufactured by Continental Specialties offer a combination of simple "go, no-go" testing and a high degree of diagnostic sophistication.

The *model LP-2* logic probe is a hand-held instrument that uses three LED indicators to display logic levels and pulse transitions via a dual-threshold window comparator and bipolar edge detector. The *model LP-2* probe is a less expensive version of the *model DP-1*; it has reduced frequency response, higher input impedance, and it lacks a pulse-memory feature.

In the *model LP-2*, a single switch selects either DTL/TTL or CMOS/HTL levels. For static tests, the upper LED illuminates when the voltage at the probe tip is within the selected logic family's high-level range. The TTL and DTL logic 1 threshold is 2.25 volts ±0.15 volt, and for CMOS and HTL, the threshold is 70% of the supply (V_{cc}) or higher. Similarly, the lower LED indicates logic levels within the low range. Logic 0 levels are 0.8 volt ±0.1 volt for TTL/DTL, and 30% or less for CMOS/TTL. No LED illumination means there is an open circuit. Observing LED's near the probe tip is much simpler and less tiring than reading a voltmeter or oscilloscope screen, and then having to mentally translate that reading to acceptable or abnormal limits.



CIRCLE 119 ON FREE INFORMATION CARD

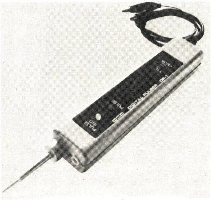
The pulse indicator flashes for 0.1 second every time the input signal makes a 0 to 1, or a 1 to 0 logic-level transition. A repetitive signal causes the indicator to illuminate constantly with an intensity that depends on duty cycle and frequency. Duty cycle is determined by observing the upper and lower LED's when the pulse light is lit. For example, if the upper LED illuminates, the signal is high most of the time and therefore consists of negative-going pulses. If both the upper and lower LED's have equal intensity, the duty cycle approaches 50% (or a squarewave).

Signals greater than 10 Hz but less than 100 kHz cause the LED to flash at a 10-Hz rate determined by the probe's 0.1-second pulse stretcher. With signals greater than 100 kHz and near 50% duty cycle, only the pulse LED is illuminated. The upper or lower LED's light as the waveform duty cycle deviates from symmetrical squarewave pulses at the higher frequencies.

The *model LP-2* operates with pulses as narrow as 300 ns and a maximum frequency of 1.5 MHz. Overload protection is effective up to 50 volts DC, or 117 volts AC, for 15 seconds. To use the probe, power must be provided through black and red clip leads that are connected to the power source supplying the circuit under test. The probe's drain is 30 mA at 5 volts and 40 mA at 15 volts; and the input impedance is 300,000 ohms.

Several accessories are available, including a 2.5-inch probe tip, hooks and adapters, and ground clips. The *model LP-2* can be used for troubleshooting an inoperative divider chain by quickly finding the defective binary stage. It could also be useful to determine the static and pulse logic conditions on IC terminals. Using this probe to examine a microprocessor's ad-

dress leads could help pinpoint a grounded bus run when compared with the other active bus lines.



CIRCLE 120 ON FREE INFORMATION CARD

The *model DP-1* is a digital pulser probe with tristate output. It resembles the *model LP-2* physically, except it has only one LED pulse indicator plus a pulse-control pushbutton. A TTL/CMOS switch chooses output logic levels. The generator produces a single output pulse for each pushbutton operation. Depressing the pushbutton transmits a 100 pulse-per-second pulse train. Depending on the present logic level of the circuit area being probed, this produces differently formed logic pulses. If the probe senses a low logic level, it generates a positive-going pulse in an attempt to switch the logic-level state high. Conversely, if the logic level is high, the probe generates narrow negative-going pulses. Connecting the probe to a variable-state point, such as a cross-connected feedback lead of a gate-wired flip-flop, generates a 50% duty cycle (continuous waveform).

In the TTL mode, the *model DP-1* produces a 1.5-μs pulse with 100-ns risetime, and 500-ns storage and falltimes with a single TTL load. The storage and falltimes decrease with increased loading. The probe drives outputs as well as inputs, as long as the combined load is within the probe's 100-mA source and heat-sink capability.

The CMOS mode produces wider pulses for the higher-impedance (and generally slower) logic family. Pulse width is 10 μs with a rise-time under 100 ns, 8-μs storage and falltimes with a 100K load, and sink and load capacity of 50 mA.

In both TTL and CMOS, the probe output is current-limited and generates continuous safety pulses into a short circuit. The LED indicator displays pulse-output states by flashing once for single pulse operation, and by constant illumination for continuous pulse-output trains.

If used with other logic probes such as the *model LP-2* or with a logic monitor that simultaneously displays all IC outputs, the *model DP-1* can test various types of logic devices. The probe is very useful in checking circuits that are only occasionally, or never activated. Using the logic pulser, these circuits can be activated repeatedly without elaborate test equipment and without disconnecting any auxiliary logic.

The *model DP-1* comes with a plug-in ground clip lead and the accessories that are available for the *model LP-2*. The output impedance is greater than 300,000 ohms when the probe is in the open-output mode. And similar to the *model LP-2*, power is supplied to the *model LP-1* via color-coded clip leads, with less than 30 mA consumption.

The *model LP-2* sells for $24.95 and the *model DP-1*, $74.95. They are both available from Continental Specialties Corporation, 70 Fulton Terrace, P.O. Box 1942, New Haven, CT 06509. **R-E**

Model 1474 $999 including probes

Model 1432 $780 including probes

For field or lab work, Dynascan has a quality scope to fit your needs. B&K-PRECISION has taken a no-nonsense, cost-effective approach to oscilloscope design. Our scopes are rugged dependable instruments, designed to match the features and performance of far more expensive scopes, without matching their high prices. Typical of this approach is our Model 1474 30MHz dual-trace lab scope and our new Model 1432 15MHz portable dual-trace scope.

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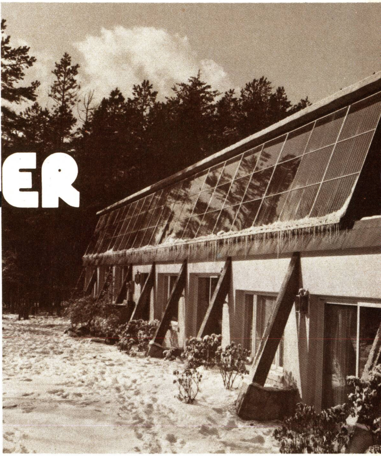
SOLAR CONTROLLER



During the present energy crisis, the sun is in the running as the most viable alternate energy source. Here's how basic electronics can be adapted to solar heating in home and industry.

RODNEY A. KREUTER

SOLAR ENERGY, IT SEEMS, HAS BECOME almost a universal interest. Companies offering solar collectors and associated hardware are springing up like glitches on a TTL breadboard. However, most companies sell complete systems and most "do-it-yourself" magazines concentrate on collectors or storage system. Very little information seems to be available concerning the instrumentation or control portion of the systems.

This article attempts to proceed one step further by providing an understanding of a simple instrumentation and control system. It is not meant to be a blow-by-blow construction guide because no two solar systems are quite the same. It is hoped that it will enable you to design a system that will meet your special needs.

Hot-water preheater

A good way to get started in solar energy is with a solar hot-water preheater. A substantial amount of the average utility bill goes to feed standard preheaters. Another advantage of a solar preheater is that the payback time is not too great and the cash outlay to get started is within reason.

A preheater is a rather straightforward device. All it does is warm up the cold-water inlet to an existing hot-water tank so that the tank itself won't need as much energy to warm the water to the required temperature. (Note the phrase "as much.") A small solar collector in a less-than-ideal climate will not supply all your needs; it will, however, help save a great deal of energy.

Figure 1 is a diagram of a hot-water preheater system. Basically, what happens is that the sun warms a water-antifreeze solution in loop 1. The pump sends the warmed solution around from the collector to a storage tank that is filled with colored water. (Colored water can be used to warn of leaks in the system.) The water in the storage tank heats up and, if the tank is well insulated, will stay warm for quite some time.

When cold water enters into loop 2, it gains heat from the storage tank and enters the hot-water heater. If the system has been well designed, the water will need just a little more energy to bring it to the necessary temperature.

The system sounds simple enough, doesn't it? Well, it has a few flaws! The sun will warm the collectors only if there is sufficient radiant energy. The storage tank will only absorb heat from loop 1 if loop 1 is warmer than the water in the storage tank. Loop 2 will be warmed only if the tank is warmer than the cold-water inlet and the hot water tank isn't full. If you don't know what the temperature of each component is, you shouldn't waste the energy used by the pump. This brings us to the LM3911.

Temperature transducers

National Semiconductor's LM3911 and the LX5600 are temperature transducers; they provide an answer to most of our temperature-measuring problems. The output of the sensors is 10 mV-per-degree Kelvin. Don't let the word Kelvin concern you; the output can be modified to read any temperature scale, but for a one-time system, the Kelvin scale is as good as any other scale. If you must convert the formula, it is: °C = °K+273.

The working temperature of the LM3911 is −25 °C to 85 °C (−13 °F to 185 °F); while the LX5600 has a range of −55°C to 125°C (−67 °F to 257 °F). Except for their range and cost, the two devices are similar.

The operation of the transducers is quite simple: Two diodes operated at two different current levels produce a voltage difference between them that is proportional to their absolute temperatures (hence, Kelvin). The output of the transducers will be about 3 volts or so, depend-

ing on how hot the IC is. (Very simple indoor-outdoor analog thermometer if you have a good VOM.)

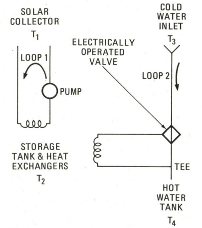


FIG. 1—BASIC SOLAR ENERGY hot-water pre-heater showing important temperature measuring points.

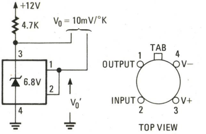


FIG. 2—BASIC SENSOR CONNECTION and pin location.

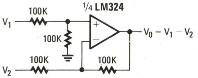


FIG. 3—DIFFERENTIAL AMPLIFIER; the power connections are not shown.

Figure 2 shows the basic connection and pin location of the transducers. Note that the output voltage of the devices is *not* referenced to ground but to pin 3.

Differential thermometer

It's useful to know the temperature of each component of the solar energy system, but it's not essential. What *is* essential is to know that component A is somewhat warmer than component B. This is the principle of the differential thermometer. The output of the thermometer is proportional to the difference of the two input temperatures. This requires a differential amplifier, which is easy to obtain using an op-amp such as the one shown in Fig. 3.

Note that the differential amplifier is based on two input voltages that are referenced to ground. Since the output of the transducers is not referenced to ground, this would seem to complicate the circuit somewhat. Luckily, there is a simple solution to this problem.

Referring to Fig. 2, note the 6.8-volt Zener diode from pin 3 to ground. This Zener diode is internal to the transducer and maintains the voltage from pin 3 to ground at 6.8.

Since V_o increases at a rate of 10-mV-per °K, and the sum of V_o and V'_o must equal 6.8 volts, V'_o must decrease at 10-mV-per °K.

Using this data, we can arrive at the differential thermometer shown in Fig. 4. The output will be proportional to the difference between temperatures T_1 and T_2 and will rise as T_1 rises, assuming that T_2 remains constant. When T_1 equals T_2, the output may not be exactly zero, because op-amps are not perfect and the 6.8-volt Zener diodes may not be exactly matched. This will not affect the operation of the circuit, and, as a matter of fact, may be used to an advantage. You should interchange the sensors if you don't get a small positive voltage (about 30 mV to 100 mV) when the sensors are at the same temperature.

Hysteresis

All control systems need some type of hysteresis, which is a type of "deadband" or buffer zone. For example, thermostats have a built-in hysteresis of about 2 °F. Assume that the hysteresis is plus or minus 1 °F of the setting. If the thermostat is set at 68 °F, the furnace will come on when the temperature falls to 67 °F and stay on until the temperature rises to 69 °F. If no hysteresis was built into the system, the furnace would cycle on and off continuously.

The hysteresis in a solar system should be fairly large—5 °F to 10 °F is not unreasonable. Figure 5 shows a comparator that is used to provide an adjustable amount of hysteresis. The LED lights as a status indicator and alarm when the set amount of temperature difference has been attained.

Interfacing

At this point, the system monitors temperature, subtracts one temperature from another, compares this value to some preset value, and lights an LED if all the conditions are met. It still won't pump much water or close a valve.

Lighting an LED has a purpose other than just providing an output of the system. When devices must be operated at 117 VAC, such as a pump or a motor, it is necessary to isolate the control system from the AC lines. By using an LED and a phototransistor sealed in a light-tight tube, a very high degree of isolation can be achieved. You can even use two LED's—one as an output and the other as part of the photocoupler.

A circuit that handles the control of

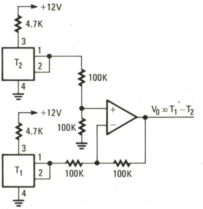


FIG. 4—DIFFERENTIAL THERMOMETER measures temperature difference.

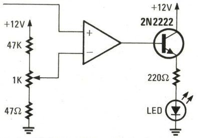


FIG. 5—COMPARATOR with hysteresis control.

the pump is shown in Fig. 6. The components might have to be scaled up or down depending on the amount of load current. And don't forget to heat-sink the triac.

Assembling the system

The complete control system is shown in Fig. 7. A regulated 12-volt power supply (see Fig. 8) is also necessary to power the system. The cost of such a supply is very low, so there is no reason to use an unregulated supply.

If you want to measure the actual temperature of one of the system components, you can use a good voltmeter.

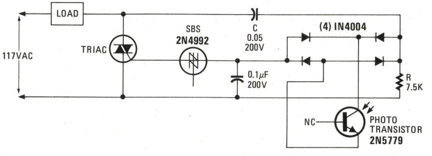


FIG. 6—LIGHT-CONTROLLED TRIAC circuit. For diac triggering, C = 0.22 µF, R = 10K. Substitute diac for 2N4992 (silicon bilateral switch) and phototransistor with V_{ceo} of 80 volts or two 2N5779's connected in series.

First, measure voltage V_s of each sensor. This (V_s) is measured from pin 3 to ground and should read about 6.8 volts. Write it down for each sensor because it will not change but will be different for each one. Any time that you want to know the actual temperature, measure voltage V_0 from the output to ground. The temperature can be found from: °C $= 100 (V_s - V_0 - 2.73)$.

A voltmeter, calibrated in degrees, can even be permanently installed in your system if you desire.

Next, you must consider the sensor. The LX5600 costs a little more than the LM3911, but it has an extended operating range and slightly better absolute accuracy. Naturally, the sensors must be thermally connected to the device to be monitored. A recommended technique would be to fabricate a heat sink that the sensor will slip into. (Use the T0-5 case.) The heat sink can then be mounted to the device. Grease the sensor with heat-sink compound (silicon grease) and slip it into the heat sink. This will prevent damage to the sensor. A solar collector should be monitored in the center if possible.

It will also be necessary to insulate and weatherproof the sensor leads. Some RTV insulation should work well. It may be possible to immerse the sensor in water if you are careful. The top of the case should have very little RTV on it to make sure it isn't thermally insulated. Another method would be to seal it in a test tube. Just make sure that the leads are well insulated.

Run shielded cable to your sensors to reduce noise pickup since open wire runs of longer than a few inches tend to produce too much noise.

Check the pump and valve specifications and choose the triac accordingly. Many different types of triacs are available, and most should work with this trigger system. Don't be afraid to experiment with different triac types.

Make sure that the phototransistor is

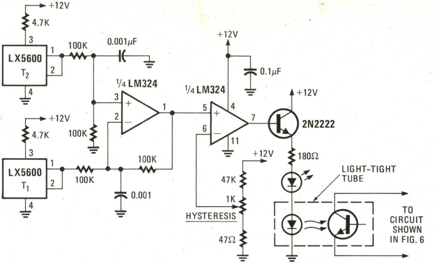


FIG. 7—SCHEMATIC DIAGRAM of complete control system. Note bypass capacitors for greater noise immunity and slight change of some component values. The LM324 contains four op-amps, so two complete loops could be handled by one IC.

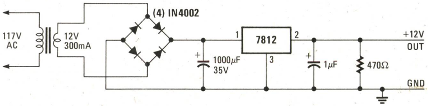


FIG. 8—12-VOLT POWER SUPPLY consists of bridge rectifier and regulator.

rated at 80 volts V_{ceo} or more if you plan to use a diac to trigger the triac. The silicon bilateral switch (shown in Fig. 6) might be hard to locate, although a GE semiconductor parts supplier should have it and the 2N5779 photo-Darlington transistor.

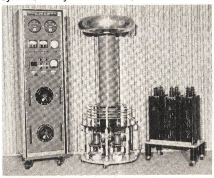
Calibrating the hysteresis control will be somewhat time-consuming. Allow one sensor to reach room temperature. This will represent the cooler component (storage tank). Feed this output into the noninverting input of the op-amp.

Prepare a warm water bath and place the other sensor in the bath (insulate the leads). This represents the warmer component (the solar collector). Feed the output of this sensor into the inverting input of the op-amp.

Now use a good thermometer to measure each temperature. Rotate the hysteresis control until the LED lights up. At this point, mark down on the dial the difference between the two temperatures. Repeat this at least five times. The total range, with the component values given, will be from about 1 °C to 20 °C. Therefore, do not raise the temperature of the bath to any warmer than room temperature plus 20 °C. **R-E**

Custom-built high-voltage Tesla coils now available

The Ultra High Voltage Division of Professional Sound Systems now manufactures a line of Tesla coils, kits and components that can be custom-built to fit individual needs. The coils are modular and symmetrically constructed, conservative in



design and can be used in high-voltage applications and for demonstrations.

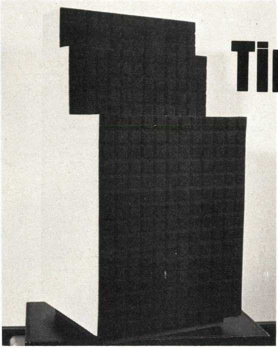
There are 10 basic configurations from which to choose, with spark-discharge lengths ranging from 1.5 inches to over 15 feet. A full line of stock components is also available, from power-supply control consoles to oscillation transformer assemblies. All of these can also be tailored to a customer's special requirements. For information, write Professional Sound Systems, Ultra High Voltage Division, 4914 Baldwin Avenue, Temple City, CA 91780.

Report states service industry salares are rising

It appears that salaries in the service industry are on the rise, according to a report entitled *Salaries and Related Matters in the Service Department—1978*, published by Abbott, Langer & Associates, Park Forest, IL.

For example, the report lists that the average national service manager's salary is presently $25,658 and that of field service representative, $13,291. The report categorizes these and other job listings by type of product or service (also by the size of the service company or manufacturer involved), as well as containing data on various types of employers. More than 25,000 positions in over 200 organizations are listed, including salaries for national regional and local service managers; field service supervisors, engineers and senior representatives; parts managers; service training instructors; technical writing supervisors; and more. Employers represented include firms manufacturing business, electrical and communications equipment; consumer electronics; computers and allied products; and medical and scientific equipment.

The report is available for $60 from Abbott, Langer & Associates, Box 275, Park Forest, IL 60466.



Time Compensated Hi-Fi Speaker System

THIS ARTICLE GIVES YOU AN OPPORTUNITY to keep up with the latest advances in loudspeaker design by showing how to build a pair of high-quality, time-compensated speakers for less than $200.

Practically any multi-way speaker system can be improved by adjusting the drivers for signal arrival time. Sound from the high-frequency speakers usually arrives first. By moving the high-frequency speakers back, the sound from the woofer, mid-range driver and tweeter can be made to arrive at your listening position simultaneously. Many of the good sounds from electrostatic speakers can now be heard with nonelectrostatic systems. Time-compensation can help produce a smoother frequency response (compared with flat baffle mounting) by reducing interference between drivers at the crossover frequency. This also produces improved transient response as well as incredible depth and stereo imaging.

The secret of proper system design is to align the *acoustic center* of each driver, as seen from the side, so that they are in the same vertical plane. Each type and size of driver has its own effective acoustic center that can be located at either the voice coil, behind the coil, or in front of it.

To locate the acoustic centers and position them correctly relative to each other, I recommend using an oscilloscope, a Bruel & Kjaer condenser microphone and a bucket-brigade audio-delay line. Each driver selected for this system has very little shift of its acoustic center through its frequency range. The crossover network is adjusted for smooth frequency response. It also maintains a uniform time response when combined with the driver time characteristics. Other kinds of drivers should not be substituted in this system since their time characteristics may not be the same.

Testing

The system should be tested for errors or a cold solder joint. Connect a 1½-volt battery across the input terminals, with the positive end going to the red terminal. The woofer cone should move out. Connect the system to your amplifier and put on FM interstation hiss. A distinct band of frequencies should be heard from each speaker—lows from the woofer, mid-frequencies from the mid-range and highs from the tweeter. These frequencies should be of approximately equal amplitude. The system can be fused with a 1½-amp normal-blow or fast-acting fuse.

The time-compensated system can be driven without stress by musical peaks of up to 100 watts. Of course, the continuous or RMS power rating of the drivers is less. Use an amplifier of 35 watts or more to avoid clipping on peaks. A severely clipping amplifier can damage the drivers and the crossover network.

Using the system

The best location for the speakers is on the floor against the long wall of the listening room. The distance between the speakers should be equal to or less than the distance from either speaker to your listening position. Avoid placing the speakers in the corners because this may provide too much bass and cause excessive room standing-wave problems. You may want to toe the speakers in toward the listening position to maintain the best time response for each speaker.

Now, you are in for a real stereo treat. In playing various types of stereo material, you will notice an unusually well-defined stereo image. You will also notice this image will vary considerably from one recording to another. Recordings made with microphones close to the instruments may sound almost monophonic in the left and right channels. A solo instrument or voice will sound almost monophonic in the center. With the microphone placed farther back and adding more of the reverberant field, recordings will have an incredible spaciousness and an evenly spread stereo image.

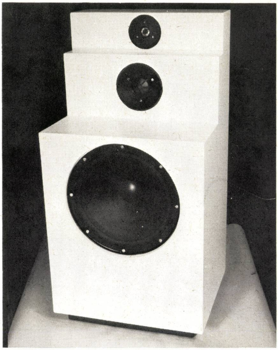
I have made many true stereo recordings using only two omnidirectional microphones. The recordings range from katydids on a summer night to church choirs. The realism of these recordings is increased dramatically with the time-compensated system. Another benefit is in transient performance. Try guitar, harp, or harpsichord recordings; then try cymbals, triangles, or snare drums.

The high frequencies in this system have been adjusted for the smoothest response. Depending on how recordings are made, however, the high-frequency balance will seem to vary. The easiest and best way to compensate for this is to use the treble control: By varying the setting from 10 o'clock to 2 o'clock, you can adjust the frequency balance for the best sound in each recording.

Once you get hooked on the superior sound from the time-compensated speaker system, you won't settle for anything less from any other system.

Here's your chance to own a state-of-the-art stereo speaker system designed so the sounds from the three drivers reach your ears simultaneously. Build it for less than $200 using ordinary hand tools.

ROGER H. RUSSELL



Cabinet construction

FOR CORRECT SIGNAL-ARRIVAL TIME, THE MID-range driver must be placed so that it is 7⅛ inches back from the woofer. The tweeter must be placed so that it is 2½ inches back from the mid-range. The result is a stepped-back arrangement whose construction is only slightly more complicated than that of a normal flat baffle design. The improvement in sound is well worth it. (Figs. 1, 2 and 3 are the construction diagrams for the front, sides and back of the speaker cabinet.)

With careful layout, many of the parts for the pair of cabinets can be made from a single 4-foot by 8-foot sheet of wood. Some lumber yards have smaller sheets available at lower cost that can be used to construct the remainder of the cabinet. A portable circular saw, a saber saw, or even a handsaw can be used to cut the panels. Visible surfaces can be painted or covered with vinyl, or wood veneer can be used.

Three-quarter-inch chipboard (also

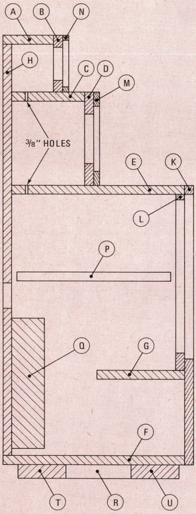


FIG. 1

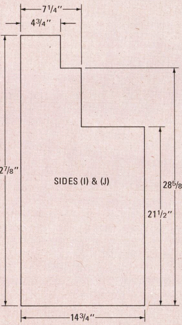


FIG. 2

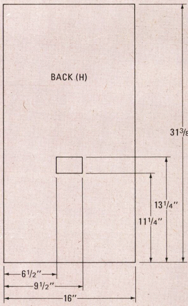


FIG. 3

called flakeboard and particle board) is recommended for strength and rigidity. You can use plywood, but voids in some plywood boards can be a nuisance when they appear at exposed edges. Oak or other hardwood bracing is necessary to further prevent cabinet vibration. To avoid counterboring holes for each of the drivers, two different boards with different-size cutouts are glued together (see Fig. 4) and the base is constructed

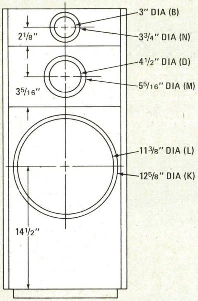


FIG. 4

from a common 2×4 (see Fig. 5). Before assembling the cabinet, cut all the required holes. Each piece should be checked for fit before it is glued and nailed in place. Check the cutouts for the speakers as well.

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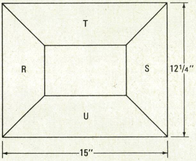


FIG. 5

Start assembling the cabinet by joining the woofer panel (shown as K in Fig. 1) to the bottom panel, F. Prior to gluing the panels together, three or four finishing nails should be hammered partway into the woofer panel. White glue should then be spread on both surfaces, the panels aligned properly and the nails driven into place.

Next, assemble one of the side panels (I or J). Nails can be partly driven into the side panel on two edges before installing. Use white glue again, this time on the side of the woofer and bottom-panel assembly. Again, align the panels and drive the nails into place (see Fig. 6). These three panels form a rigid assembly that can be put aside for the glue to set.

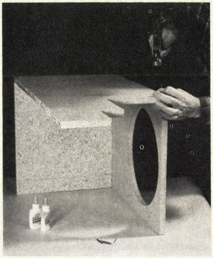


FIG. 6

Next, add the other side panel, which can be installed similarly (see Fig. 7). The remaining panels can be added, working toward the top of the enclosure. Continue to check each

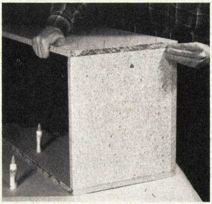


FIG. 7

part for fit before adding it to the assembly. The last major part to assemble is the back, H. Before installing the back permanently, be sure the woofer subpanel, L, and braces G, O and P are in place (see Fig. 8). Run a bead of glue around the joints in the woofer section to form a good seal. Finally, make sure the two ³/8-inch holes are drilled in panels C and E to allow passage of wires from the crossover network to the mid-range driver and tweeter circuits. After the back is installed, brace Q can be glued in place (see Fig. 9).

This completes the cabinet assembly. All the remaining components are installed from the outside. The cabinet can be completely finished at this time. I painted the entire enclosure with several coats of white vinyl Latex paint (see Fig. 10). Prior to painting,

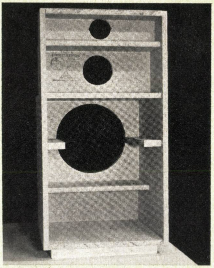


FIG. 8

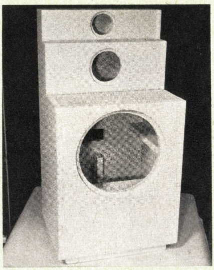


FIG. 9

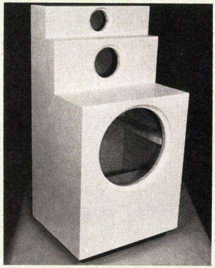


FIG. 10

you should fill all cracks with wood filler compound and sand the entire enclosure thoroughly.

Crossover

The heart of any good multi-way

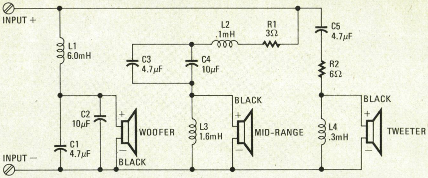


FIG. 11

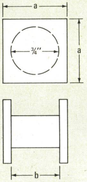
speaker system is the frequency-dividing network. Numerous listening tests as well as acoustic response measurements were made to insure that each speaker output complements the others closely in frequency range and amplitude. The frequency-dividing (crossover) network, (see Fig. 11) was adjusted for best performance using Norelco (Philips) drivers (Fig. 12).

The network board is made of ½-inch particle board and is 7 inches square. A push-type connector is mounted on the opposite side of the components (see Fig. 13) so that it will be in the hole in the enclosure's back panel (H). The four coils are wound as detailed in Fig. 14. Coil forms are made from squares of ⅛-inch thick Masonite glued to ¾-inch-diameter dowels. Three different coil forms are used for the four coils in the network, which are made of ordinary enameled magnet wire. The number of coil turns is based on "scramble" winding. This means neat orderly rows of turns are not necessary. However, windings should be kept reasonably tight. The finished 6-mH coil weighs about 1¼ lb. Gluing the ends of this coil form will not be sufficient. Drive *brass* screws through the faces into the dowel to be sure the coil form stays together.

Coils can be started by winding a few turns of wire around your finger and then taping this wire to one face of the coil form (Fig. 15). The coil can then be wound. After the coil is wound, wrap tape around the turns to hold them in place. The tape holding the wire on one coil form face can then be removed and both leads cut off at a length of about 3 inches from the form. Then scrape the insulation from the lead ends and tin the wires with solder.

The electrolytic-capacitor losses are sufficiently low not to affect the output of either the mid-range driver or tweeter. In the woofer and the mid-range circuit, 10- and 4.7-μF capacitors are connected in parallel to produce a total capacitance close to 15 μF. The resistors in series with the mid-range and tweeter are 5-watt "cinder-block" types. All components, particularly the 6-mH coil, should be well glued to the board to hold them in place and prevent vibration. I recommend using RTV silicone adhesive for this purpose.

Wiring of the board is a perfectly straightforward procedure using terminal strips and mounting hardware. Component placement is shown in Fig. 16. Number 20 stranded wire with color-coded insulation is adequate as leads to the speakers. Use black-colored wire for the negative lead on all the drivers. The following wire lengths should be used: the tweeter, 24 inches; the mid-range, 20 inches; and the woofer, 21 inches.



COIL	a	DOWEL LENGTH b	WIRE SIZE	NUMBER OF TURNS
L1-6.0mH	2½"	1½"	#18	675
L2- .1mH	1"	½"	#24	77
L3-1.6mH	1½"	1"	#22	338
L4- .3mH	1"	½"	#24	133

FIG. 14

FIG. 12

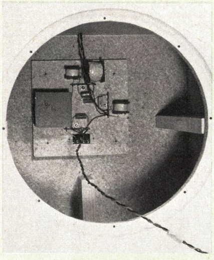


FIG. 13

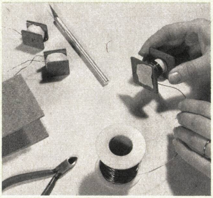


FIG. 15

Final installation

Place caulking compound around the inside of the crossover opening in the back panel and then push the crossover panel into place. The compound holds the board while you center the terminal in the cutout. Start drilling ⁷⁄₆₄-inch-diameter screw holes in the back of the cabinet using the holes in the crossover panel to locate them (see Fig. 13). Drill only partway into the cabinet back. Using No. 8 × 1-inch sheet-metal screws, fasten the crossover panel in place. Dress the purple and black tweeter wires from the crossover through the ⅜-inch holes in E and C and out of the tweeter cutout. The orange and black wires go through the ⅜-inch hole in E and out of the mid-range driver cutout. Seal this ⅜-inch hole with caulking compound to create an airtight woofer compartment. The red and black woofer wires can be brought out and taped to the front of the cabinet.

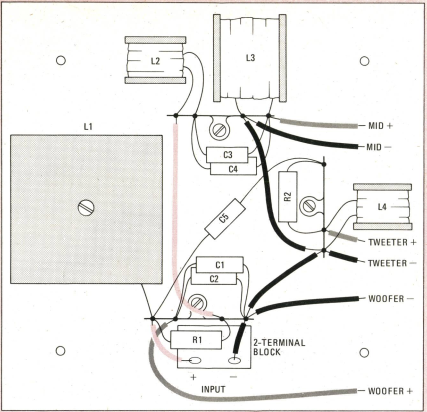


FIG. 16

With a driver in place, use the mounting holes as guides to drill the screw holes into the mounting board. For the mid-range driver and tweeter, use a 5/64-inch drill. The mounting holes for the woofer are 9/64 inch.

Next, fill the woofer compartment with glass-fiber insulation material (Fig. 17). Ordinary pink home insulation material 2 or 3 inches thick can be

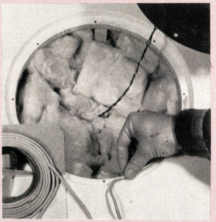


FIG. 17

used. A roll of this insulation costs less than the small packages of acoustic glass-fiber material needed to fill two systems. Insulation performance is the same or better, and you can use the remainder in your attic or under the hood of the family car.

Remove the vapor-barrier backing and cut the glass-fiber into small pieces. This will produce the smoothest bass response. Three-inch cubes will do nicely, although size is not too critical. Wear rubber gloves to avoid possible irritation to your hands. Fill the enclosure completely with loosely packed insulation material. And make sure to fill under the brace, G. No material is needed in the upper compartments because both the mid-range driver and the tweeters have sealed backs. The drivers can now be connected and installed.

Solder the color-coded wire to the positive terminal and the black wire to the negative lead. A red mark on or near the terminal indicates it is positive; if no mark appears, briefly connect a 1½-volt battery to the terminals. When the speaker diaphragm moves away from the magnet, the positive end of the battery is connected to the positive lead of the speaker. The mid-range driver and tweeter can be installed using No. 6 × ½-inch sheet-metal screws. The woofer can be installed with No. 10 × ¾-inch sheet-metal screws. Place caulking compound only around the woofer; it should be placed between the woofer basket and the woofer subpanel, L (see Fig. 18). Again, this insures a seal in the woofer compartments.

The foam grille can be cut and installed using the self-adhering strip that comes with the grille along with cutting instructions. Three grille packages are all that are needed to cover two systems. This completes the assembly. **R-E**

SPEAKER SYSTEM PARTS LIST

The following items are available from McGee Radio & Electronic Corporation, 1901 McGee Street, Kansas City, MO 64108:

Part No. AD12250 W8: Two 12-inch Norelco woofers, two for $77.

Part No. AD0211 SQ8: Two 2-inch soft-dome Norelco mid-ranges, $19.95 each. (This part not in McGee catalog but available.)

Part No. AD0162 T8: Two 1-inch dome tweeters, $9.95 each.

Two 3-ohm 5-watt resistors, $.20 each.

Two 6-ohm 5-watt resistors, $.49 each.

The following items are available from Radio Shack stores:

Part No. 272-999: Four 10-μF, 50-volt nonpolar capacitors, $.99 each.

Part No. 272-998: Six 4.7-μF, 50-volt nonpolar capacitors, $.89 each.

Part No. 274-688: Two 5-lug terminal-strip packs of 4, $.69 each.

Part No. 274-621: Two terminal boards, $.99 each.

Part No. 40-1951: Three foam grilles, $5.95 each.

Miscellaneous: One roll of glass-fiber insulation (approximately $5.95); two 4-foot by 8-foot sheets of ¾-inch particle board ($17); five ½-lb (100-foot) rolls No. 18 magnet wire; two ¼-pound (93-foot) rolls No. 22 magnet wire; two ¼-pound (150-foot) rolls No. 24 magnet wire; white glue ($1.79); eight No. 8 × 1-inch sheet-metal screws; 16 No. 10 × 1-inch sheet-metal screws; 14 No. 6 × ½-inch sheet-metal screws; 2 flat-head brass wood screws; hookup wire; solder; paint; caulking compound; hardwood bracing; 8-foot-long two-by-four; 1¼-inch finishing nails.

CABINET LUMBER DIMENSIONS

To construct the cabinet for the time-compensated speaker system, the following lumber should be purchased:

¾-inch-thick flakeboard:

Top panel (A): 3⅝ inches × 16 inches
Tweeter board (B): 4¼ inches × 16 inches
Tweeter bottom (C): 5⅜ inches × 16 inches
Mid-board (D): 7⅛ inches × 16 inches
Woofer top (E): 13¼ inches × 16 inches
Woofer bottom (F): 14 inches × 16 inches
Mid-brace (G): 6¾ inches × 16 inches
Back panel (H): 31⅜ inches × 16 inches
Side panels (I & J): 32⅞ inches × 14¾ inches (see Fig. 2)
Woofer board (K): 21½ inches × 16 inches
Woofer board (L): 13¼ inches × 16 inches

⅜-inch-thick flakeboard:

Mid-board (M): 7⅛ inches × 16 inches
Tweeter board (N): 4¼ inches × 16 inches

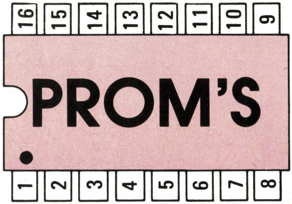
¾-inch hardwood:

Braces (O & P): 12 inches × 2½ inches
Brace (Q): 10 inches × 2½ inches

2 × 4 inch fir:

Base (R & S): 12¼ inches
Base (T & U): 15 inches

Making PROM'S Work For You



The programmable read-only memory is becoming the workhouse of modern digital electronics and will play an ever-increasing role in your everyday activities. Here is what it's all about.

ROBERT H. PENOYER

THE PROM (PROGRAMMABLE *R*EAD-*O*NLY *M*emory) is increasingly being accepted as a circuit element. The electronic hobbyist or home computer owner should become familiar with this very useful device. Because there have been numerous articles written about both the PROM and the EPROM (*E*rasable PROM), this article will just briefly mention their theory of operation, and concentrate on the ways these devices can be put to use.

What is a PROM?

Figure 1 shows the basic configuration of a 16 × 4-bit PROM; that is, there are 4 address lines, and, therefore, $2^4 = 16$ states can be represented. Each of these 16 states is decoded into a single control line that leads to a set of junctions in the memory array. These junctions are either closed or fused open depending upon how the PROM is programmed. The logic state of the junctions selected by the address decoder passes through the buffer and appears at the output. Figure 1 shows 4 output lines; thus, there are $2^4 \times 4$ or 16 × 4 junctions. This PROM can also be described as containing 16 words with 4 bits-per-word. There are as many words as there are address states. Therefore, if the PROM had eight address lines and one output line, it would be a $2^8 \times$ 1-bit or a 256 × 1-bit PROM, or containing 256 1-bit words.

Just as there are closed or fused-open junctions in a PROM array, the EPROM uses static charges on MOSFET transistors to achieve the effects of an open or closed junction. The charges on the MOSFET's can last for years or be erased in a few minutes by special ultraviolet lamps.

Using the PROM

The PROM serves two main purposes: First, a single PROM IC can replace an entire multiple-gate logic array. Say, for example, you needed a set of gates that would perform the function described in the truth table of Fig. 2. If standard gates were used, a complex network would result. Instead, let the four left-hand columns of Fig. 2 represent the address lines, and let the column on the right represent the output line of a 16 × 1-bit PROM. Thus you would achieve the desired function using only a single IC. The result is a savings in wiring time, troubleshooting time and board space.

The second main use of a PROM is as a "look-up table." For example, suppose you wanted a counter to count in the sequence shown in the right-hand side of Fig. 3. This could be extremely difficult to accomplish using ordinary logic. Instead, you can apply the output lines of an ordinary binary counter to the address lines of a PROM. Upon reaching any of the 16 possible states, the counter causes the internal logic of the PROM to "look up" the desired output state and pass it through its buffer to the output, according to the truth table. Only two IC's, a 4-bit binary counter and a PROM are needed to arrive at a rather complicated sequential output.

Another example of using a PROM as a look-up table is a Baudot to ASCII code translator. The Baudot code can act as the address for a PROM, and the PROM output can yield equivalent ASCII characters.

Propagation delay and access time

As with any logic device, propagation delays in PROM's are important, particularly so if a PROM's output lines are used to drive counters or clocked logic of any type.

A specifically limited amount of time is required to receive an address, decode it, drive a set of junctions in the PROM array and transmit the result through the buffers to the PROM output. This is called the PROM's access time, and is

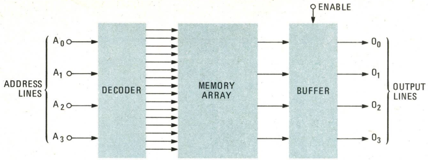


FIG. 1—PROM consists of an address decoder, output buffer and memory array.

A_0	A_1	A_2	A_3	F
0	0	0	0	1
0	0	0	1	1
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

FIG. 2—COMPLEX LOGIC FUNCTIONS such as the one shown in the above truth table can be easily handled by a PROM.

A_0	A_1	A_2	A_3	O_0	O_1	O_2	O_3
0	0	0	0	0	0	1	0
0	0	0	1	0	1	0	0
0	0	1	0	0	1	0	0
0	0	1	1	1	0	1	1
0	1	0	0	1	1	1	0
0	1	0	1	0	1	1	1
0	1	1	0	1	0	1	1
0	1	1	1	1	1	0	1
1	0	0	0	1	1	1	0
1	0	0	1	1	1	0	1
1	0	1	0	1	0	1	1
1	0	1	1	0	1	1	1
1	1	0	0	1	1	1	1
1	1	0	1	0	0	0	0
1	1	1	0	1	0	0	1
1	1	1	1	1	0	1	0

FIG. 3—COUNTERS with an unusual counting sequence can easily be designed using a PROM.

listed in the manufacturer's data sheet. During the access delay time, the state of the output lines on a PROM is unpredictable. A set of outputs can pass through several states during the transition from one address to the next. Therefore, if the outputs are driving clocked logic, the logic could receive undesired data. Obviously, this should not be allowed to happen. Luckily there are methods to get around this problem.

Buffer and latch isolation

As shown in Fig. 1, the output buffer of the PROM often has an enable control line. Typically, this enable line is used to select the device that is to be connected to a parallel bus system when many such tri-state devices are used. When enabled, the buffer outputs are at normal logic levels. When not enabled, the buffer outputs appear to be open circuits. If all the buffer output lines are pulled to +V through, say, 10K resistors (in the case of TTL logic) then when the output lines are disabled they will be at a known high logic level. Therefore, no output line can go low unless that particular bit was programmed low and the PROM output was enabled. Thus, it is only necessary to disable the output when changing addresses. Using such an arrangement, no glitches appear at the output and low-going pulses appear only when desired. Figure 4 shows a typical circuit using this technique.

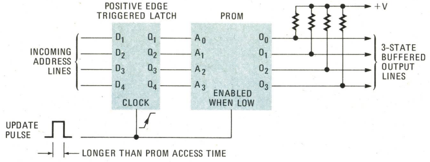


FIG. 4—DISABLING PROM during access time prevents glitches from appearing at the output.

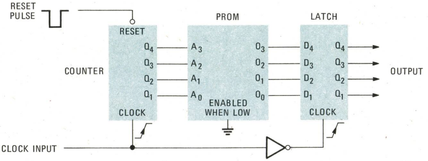


FIG. 5—CLOCK SIGNAL in synchronous circuits can be used to inhibit output during access time.

You can use a similar more desirable technique that requires no pull-up resistors on the buffered output lines. Let's say, for example, you want a circuit that counts as shown in the Fig. 3 truth table. Also assume that you could not arbitrarily allow the outputs to go high, as shown in Fig. 4.

Figure 5 shows an alternative technique: a synchronous binary counter drives the address lines of a PROM that is programmed according to the truth table shown in Fig. 3. Therefore, as the counter passes through each binary state, the desired output appears on the PROM output lines. These lines are always enabled as shown in Fig. 5. Note that both the counter and the latch are triggered by positive-going clock edges, and there is an inverter in the latch clock line. This means that while the counter still triggers on the positive-going edge of the clock, the latch will trigger on the negative-going edge. This provides a delay of one-half clock period between the time the counter is updated and the resulting PROM output appears at the latch output. If the PROM access time is shorter than one-half clock period, its output will be settled by the time the latch uses it. The result is a clean accurate set of waveforms at the latch output.

PROM sources

PROM's and EPROM's are available in many configurations. Just check through manufacturers' catalogs for the type of PROM you need for your application. Sometimes the required number of words and word length are not available and you have used a PROM with more words or bits than you need. In this case, you should consider the economics of wasting PROM capability.

Most large distributors can program a PROM for you if you purchase it from them. Find out all the necessary information before placing the order for your PROM; often the distributors will program the device for a small fee or at no additional cost. **R-E**

NOM Card For The 1802

Add-on math board for an 1802-based microcomputer. Based on a number-crunching IC, this board speeds execution time, reduces software overhead and saves memory

L. STEVEN CHEAIRS

NOW THAT YOU HAVE YOUR RCA 1802-based microcomputer up and running, what do you do next? You might consider putting it to some serious work, but in doing so, you will probably run into the software wall. In other words, for most applications a good deal of programming will be required, and a good portion of it will be for mathematical operations. It's also a known fact that you can age very rapidly writing all the software needed to perform the required mathematical operations.

One alternative is to use hardware instead of software to perform these operations. The first idea I had was to use a scientific calculator IC. This would certainly reduce the software development time, leaving me only the interfacing to worry about. While this apparently solves the software problem, it creates a Pandora's box full of new ones.

First, most calculator IC's have on-chip debounce circuitry designed to solve the problems generated by multiple character entry due to noisy keyboard switches. This is a very positive feature for a calculator, but, unfortunately, it tends to slow a microprocessor down.

Second, a calculator IC in its natural habitat is interfaced to a keyboard via a set of multiplexed input/output (I/O) pins. This requires complex interfacing to convert incoming data into the signals necessary to imitate a keyboard switch. While this is not an impossible task, it is a bit messy.

Third, a calculator is designed to stand alone, not act as a slave processor for a microcomputer system. The data is outputted in a multiplexed 7-segment, non-TTL format. Multiplexing data is not only acceptable but desirable. On the other hand, a 7-segment format is not exactly the easiest format for a computer to manipulate. It could of course be converted to a BCD (*B*inary-*C*oded *D*ecimal) format by several methods, such as a software look-up table, or a PROM could be programmed to convert a minimum of five input lines into the four BCD output lines. Another point to consider is that the calculator IC's do not have the control lines required to interface it to the processor.

You could try another approach, such as dedicating a CPU and a ROM as a mathematical processor. National Semiconductors has done just that with its new Number-Oriented Microprocessor (NOM). This special-purpose microprocessor, the MM57109, is available through distributors. This single IC will provide most, if not all, of the mathematical operations needed for any computer system. The software overhead is drastically reduced when this processor is used.

The MM57109

Figure 1 is the internal block diagram of the MM57109, showing both the signal lines and their point of origin. The internal register file is composed of five

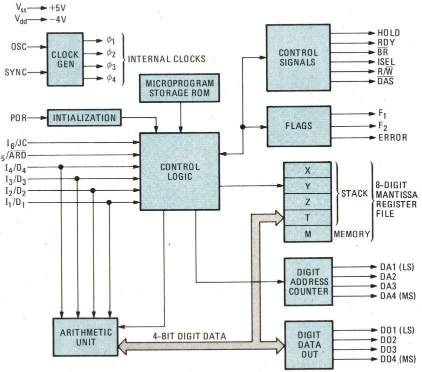


FIG. 1—BLOCK DIAGRAM OF THE MM57109 number-oriented microprocessor.

registers (X, Y, Z, T and M); each has eight mantissa digits, two exponent digits, a decimal-point position indicator, and the mantissa and exponent sign bits. The program-storage ROM stores about 1500 eight-bit micro-instruction words. The 6-bit-long program instructions enter through the $I_{1\text{-}6}$-lines and are converted into a sequence of these micro-instructions. The BCD data words enter the control logic via the $I_{1\text{-}4}$-lines.

Data is outputted, after receiving the OUT instruction, through the digit-data-out block. The digit-address-counter block sequences each digit during the I/O operations. The Read/$\overline{\text{Write}}$ control line is used during the OUT instruction to latch the data words into the interface register.

Figure 2 shows a table of the MM57109's important features. These features can be classified into four categories: scientific calculator-type instructions, I/O, branch control and interface.

Basically, the MM57109 looks like an RPN (*R*everse *P*olish *N*otation) scientific calculator. The only major difference is in the I/O and control-interface circuitry. National Semiconductor engineers state that the MM57109 is a *modified* scientific calculator. First, we'll take a look at the 1802-type interface; then, the instructions and programming techniques will be discussed. If you are not yet convinced that the MM57109 is the way to go, then look at Table 1. As stated earlier, the NOM is very easy to interface to almost any computer system. The MM57109 is only one of two NOM interfaces that Questar Engineering is marketing; the other is for the S-100 bus.

Instructions	Input/Output	Branch Control	Interface
RPN	HOLD for asynchronous and single step operation	Conditional and unconditional program branching	Single phase clock
1 to 8-digit mantissa	Asynchronous digit input instruction (AIN) *with* AIN ready (ADR) input	Increment/decrement branch on non-zero for program loops	Low power operation
2-digit exponent	Multidigit I/O instructions (IN, OUT)		Generation of I/O control signals
Four-register stack, one-memory location	Floating point or scientific notation		Separate digit input, output, and address bus
Trigonometic functions, logarithmic functions, Y^x, e^x, π, etc.	Programmable mantissa digit count for IN, OUT instructions		
Error Flag	Sense input and flag output		

FIG. 2—FEATURES OF THE MM57109 that are important to the NOM card constructor.

TABLE 1—Comparison of MM57109 to the Average Microprocessor and Calculator IC's

	MM57109	MICROPROCESSOR	CALCULATOR
Speed (math or I/O)	0.5–400 ms	0.5–500 ms	14–400 ms
Data length	Variable (1- to 8-digit mantissa)	Fixed	Fixed
Data format	Floating point, and scientific notation	Binary	Floating point, and scientific notation
I/O	Multidigit, asynchronous digit and single bit	Data bytes and single bit	Keyboard/display
Program	External ROM/PC, μP or FIFO	External ROM, internal PC	Key sequence

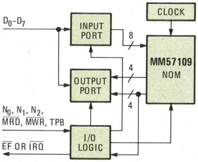


FIG. 3—1802 MICROPROCESSOR INTERFACE for the MM57109.

Circuit operation

The basic circuit operation is shown in the block diagram of Fig. 3, while the complete schematic is shown in Fig. 4. The I/O signals (N_0, N_1, N_2, TPB, $\overline{\text{MRD}}$, $\overline{\text{MWR}}$) from the 1802 are decoded, and are used to move data into and out of the NOM via two 8-bit data latches. One-half of the data output port, D_0–D_3, is the

PARTS LIST

All resistors ½ watt, 5% unless noted.
R1-R5, R17, R18—10,000 ohms
R6—300 ohms, ½ watt
R7—1000 ohms
R8—18,000 ohms
R9, R10, R12-R15—2000 ohms
R11, R16—9100 ohms
C1, C5—1-μF, 35-volt, electrolytic
C2, C3, C8, C11, C12—0.01-μF, disc
C4, C9, C10—100-pF, disc
C6, C7—10-μF, 20-volt, electrolytic
D1—1N703 Zener diode (or equal), 3.9 volts
IC1, IC2—4508, dual 4-bit latch
IC3, IC13—4069, hex inverter
IC4—4073, triple 3-input AND gate
IC5, IC6, IC8—4013, dual D-type flip-flop
IC7—4049, hex inverter buffer
IC9—4528, BCD-to-decimal decoder/binary-to-octal decoder
IC10—DS8800, dual TTL-to-MOS voltage converter
IC11—MM57109, NOM
IC12—4072, dual 4-input OR gate
S1-S4—DIP switch (8 SPST switches)
Misc.—One 28-pin DIP socket for IC11, and a PC board.

The following are available from Questar Engineering Co., 50 S. MacDonald St., Mesa, AZ 85202:
PC board, predrilled and etched, $33
Complete kit of all parts, $98
Elf II to SB-44 converter card, $6.95
MM57109 NOM IC, $18
DS8800 TTL-to-MOS converter IC, $6.45.

Questar also has a PROM containing a subroutine that will perform all the power-up housekeeping and FIFO interface between the 1802 and the NOM. Also included on the PROM is a monitor-type software package, $28.50.

Note: The decision to use a dual 22-pin card was based on the fact that this card has been a standard component of the electronic field for many years. The Vector-size card and hardware are readily available and less expensive than other components. There are a variety of other printed-circuit cards using this same bus, a few of which will be available in the future. These PC cards include a Vector-type graphic display that uses an oscilloscope as a display; a 2K-byte EROM/2K-byte low-power RAM card; and a nonvolatile 4K-byte RAM board; the EROM's are programmed in place on the card. This permits the EROM to be treated like a RAM, plus a program can be developed in RAM and transferred to EROM without unplugging any components. The program can then be executed immediately from the EROM.

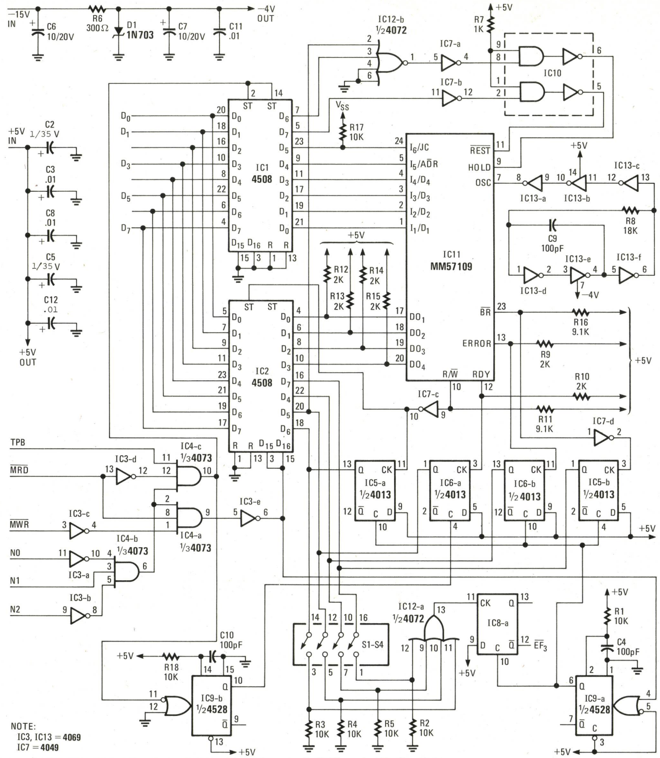


FIG. 4—COMPLETE SCHEMATIC FOR THE NOM interface. The top end of R17 goes to +5 volts which is equivalent to V_{ss}. The −4-volt level is equivalent to V_{dd}.

BCD data from the NOM, while the other 4 bits are used to provide status information to the 1802 CPU. Note that the address counter digit from the NOM is not provided. This is because the address digit requires 4 bits of the I/O port (thus requiring a second output port). This may seem like a poor decision just to save one output port, but it is not. The output format of the NOM is defined by the internal architecture, and with a minor amount of software added to the 1802's program, the same information may be derived. Figure 5 shows the data formats for both the scientific-notation mode and Fig. 6 shows the floating-point mode.

The other 4 data bits inform the 1802 of the NOM's status; also any of these 4 bits can be configured to output an active low signal, which should be used to set one of the event flags or initiate an interrupt. Bits D_0–D_5 of the input port supply the instructions to pins I_1–I_6 pins; input data is placed on the D_0–D_3 lines and enters through I_0–I_3. The 1802 uses the upper input data, bits D_6 and D_7, to reset and/or halt the NOM. This data is shown in Fig. 7, along with port decoding information.

The control logic is actually quite simple; and in fact, the whole circuit is also very simple. It can be described in three parts—the *input decode*, the *NOM status register* and the *interrupt request circuitry*.

The input decode circuit is formed by IC3, IC4 and IC9-a. These IC's are used to decode $\overline{N}_0$, N_1, $\overline{N}_2$, MRD, and TPB

($\overline{N}_0$.N_1.$\overline{N}_2$.MRD.TPB), and to clock data and/or instruction into the input buffer. The product of $\overline{N}_0$, N_1, $\overline{N}_2$, $\overline{MRD}$, and MWR ($\overline{N}_0$.N_1.$\overline{N}_2$.$\overline{MRD}$.MWR) is used to enable the output buffers allowing status information and data from the DO_0–DO_3 output of the NOM to be transferred to the 1802. One-shot IC9-a produces a pulse on the falling edge of control line N2, which is used to reset input-ready flip-flop IC6-a.

The NOM status register is formed by one-half of the output buffer, IC_2 (bits D_4–D_7), and four D-type flip-flops along with two inverters. The least significant bit, D_4, is the error flag; eight possible types of errors are shown in Table 2.

TABLE 2—Error Conditions of the MM57109 NOM

1. LN X and LOG X when X 0
2. When any result is 10^{-99} or 10^{100}
3. When TAN 90°, 270°, 450°, etc.
4. SIN X, COS X, TAN X for X 9000°
5. $SIN^{-1}X$, $COS^{-1}X$ for X 1 or X 10^{-50}
6. For SQRT X when X O
7. For /, INV, 1/X when X = 0
8. In the floating-point mode for the OUT instruction if the number of digits to the left of the decimal point is equal to the Mantissa Digit Count.

Whenever an error occurs, an ECLR (*Er*ror *F*lag *C*lear) instruction must be executed. The error flag can be tested at any time by the TERR instruction, a branch-type instruction (branches if ERROR = 1). The 1802 can also check this condition by reading the D_4 bit of the output port; this bit is reset after its access. Bit D_5 is the input-ready signal; it indicates the NOM is ready to execute the next instruction or to get the second word of a two-word instruction.

In order to permit asynchronous operation between the 1802 and the NOM on the rising edge of bit D_5, the NOM is placed into a hold state, hold = 1. When flip-flop IC6-a is reset by control line N2 (as stated earlier, this occurs on the falling edge of control line N0, which is used to load new instructions into the input port) the NOM will execute the next instruction. When the user's program is informed by bit D_5 that the input is ready, then the program provides the next instruction to the NOM.

Bit D_6 is the output-ready signal. Upon receiving this information, the user program stores the data into a software FIFO—a table in memory that acts like a first-in/first-out memory. The reason that a software FIFO is needed is due to the method in which the NOM outputs data. An OUT instruction is sent to the NOM, which, in turn, causes the NOM to output the first digit. Ten microseconds later, the output-ready flip-flop is set, and the DO_1–DO_4 output bits are clocked into the lower bits (D_0–D_3) of the output port. This data must be read and

DA_4-DA_1	IN: D_4 OUT: DO_4	D_3 DO_3	D_2 DO_2	D_1 DO_1
0	Most Significant	Exponent Digit		
1	Least Significant			
2	Sign (Mantissa)	0	0	Sign (Exponent)
3	Unused			
4	Most Significant Mantissa (Followed by Decimal Point)			
.	.			
.	.			
.	.			
Mantissa Digit Count + 3	Least Significant Mantissa Digit			

FIG. 5—IN/OUT INSTRUCTIONS (Scientific Notation Mode).

DA_4-DA_1	Decimal point position	IN: D_4 OUT: DO_4	D_3 DO_3	D_2 DO_2	D_1 DO_1
2		Sign (Mantissa) 0		0	0
3		Decimal Point Position			
4	11	Most Significant Mantissa Digit=0-9			
.	10	.			
.	.	.			
.	.	.			
Mantissa Digit Count + 3	12-Mantissa Digit Count	Least Significant Mantissa Digit=0-9			

Where: DA_1-DA_4 is the digit address
DO_1-DO_4 is the digit data out
D_1-D_4 is the digit data in

Also: The mantissa digit count is set by the SMDC instruction, initially it is equal to eight.
For the sign of the mantissa zero represents positive and one represents negative.
The sign of the exponent is equal to zero in the floating point node.
The decimal point position indicator is a value in the range from 11 down to (12-mantissa digit count), which indicates a digit, as given by the decimal point position indicator column in the table. The decimal point is located to the right of this digit.

FIG. 6—IN/OUT INSTRUCTIONS (Floating-Point Mode).

D_7 … D_0

R	H	I_6	I_5	I_4	I_3	I_2	I_1

a

D_7 … D_0

BR	OR	IR	ER	D_4	D_3	D_2	D_1

b

At: TPB=1
When: N_0=0, N_1=1, N_2=0, $\overline{MRD}$=0

At: $\overline{MWR}$=0
When: N_0=0, N_1=1, N_2=0, $\overline{MRD}$=1

Where: R is reset,
H is hold,
I_1-I_6 is the instruction inputs,
D_1D_3 is the digit data out,
BR is the branch output,
OR is the output ready,
IR is the input ready,
ER is the error output.

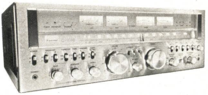
FIG. 7—PORT FORMAT. a) Input; b) Output.

the flip-flop cleared (by reading the port) within 140 μs because the second digit will be outputted at that time. Every 140 μs, a new digit will be made available, along with a data-ready signal, until the full number is outputted. The last bit, D_7, is the branch signal. This signal indicates a program branch has been encountered; input ready is set during this signal.

The interrupt-request circuitry is formed by the 4-input OR gate, IC12-a, and the D-type flip-flop, IC8-b, along with a DIP switch and four pull-down resistors. The four status signals (error, input ready, output ready and branch) are connected to a 4-input OR gate via a set of SPST switches, along with the pull-down resistors. This permits any of the status signals to clock a logic 1 into the D-type flip-flop, providing a total of 16 possible interrupt (or event-flag) conditions. For example, if you're only interested in knowing when the output is ready (this implies that no branch instructions are to be used, that the data/instructions inputted are free of errors, and sufficient time is allowed between instructions so that a new instruction can never be inputted in the middle of an instruction already being executed), then all but the output-ready switches are opened. Thus, a logic 1 is clocked into IC8-b only when the output-ready signal is active. The $\overline{Q}$ output relays this information to the 1802 via either the $\overline{IRQ}$, or one of the four event flags ($\overline{EF}_1$,

continued on page 79

Radio-Electronics Tests Sansui G-9000 AM/FM Receiver



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CIRCLE 104 ON FREE INFORMATION CARD

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

SANSUI'S TOP RECEIVERS THIS YEAR ALL feature a DC-configured power-amplifier section. This means that there are no input coupling capacitors to the power section, and that all capacitors in the feedback network have been eliminated. The advantages claimed for this circuitry are in improved transient response (lower transient intermodulation distortion) and a frequency response that goes right down to DC. The audible difference between an AC-coupled amplifier and a DC-coupled one may be subtle to inexperienced listeners, but serious audiophiles report somewhat cleaner and more accurate sound reproduction from such DC-configured circuits.

From our point of view, the Sansui *model G-9000* offers a good deal more than just a DC amplifier. The front panel, shown in Fig. 1, is loaded with features that will delight the audio buff seeking maximum control and flexibility. The light-colored, sloped frequency scales (the FM scale is linearly calibrated with markings at every 200 kHz) are surmounted by four well-illuminated meters, two of which are power-output meters, logarithmically calibrated from 0.1 watt to 300 watts (referred to 8-ohm loads). The other two meters are signal-strength and center-of-channel indicators for the tuner. To the left of the meters are four indicator lights, two showing which speaker pair is activated; the other two serve as a power-on indicator and a "protector" indicator. The protector indicator flashes intermittently for a few seconds when the power is first turned on until voltages have been fully stabilized, after which sound is heard from the speakers.

Five indicator lights to the right of the meters denote the program source selected. A series of positive-feel toggle switches just below the dial area to the left handle power, speaker selection, bass and treble control turnover frequencies (200 Hz or 400 Hz for the bass control, 3 kHz or 5 kHz for the treble), tone control defeat and −20 dB audio muting. Similar toggle switches to the right handle FM muting, stereo or mono listening modes, 25-μs or 75-μs de-emphasis, FM noise filter and wide or narrow bandwidth for the FM IF circuits. A microphone mixing level control and microphone input jack are located at the extreme lower right-hand side of the panel.

Major controls along the bottom of the front panel include BASS, TREBLE and MID-RANGE tone controls (each with fixed, detented steps for easy resetting), balance control, program SELECTOR switch and TAPE MONITOR switch (with positions for monitoring either of two connected tape decks or dubbing from one to another). Two massive knobs in the center of the panel take care of frequency tuning (the smoothest-acting flywheel-dial arrangement we've ever experienced) and master volume-control settings. The volume control contains an index tab that can be set at preferred maximum listening levels. Its clutch-like action prevents the volume control from being accidentally turned to overload or excessive listening levels—a nice feature if there are young children in the house who might inadvertently turn the volume all the way up and destroy speaker voice coils in the process! Three square pushbuttons between these two large controls activate subsonic and high-cut filters as well as the loudness compensation circuits. A similar pushbutton near the program selector switch provides a third circuit-interruption point for the insertion of a four-channel adapter, graphic equalizer, audio time-delay unit, or a Dolby noise-reduction adapter. A headphone jack just below the POWER switch on the lower left completes the panel layout.

The rear panel of the *model G-9000* contains three AC convenience outlets (one switched, two unswitched). One of the most pleasing physical features of this receiver is how the input/output jacks and terminals are positioned. These connections are located in recessed areas in the *side* wood panels of the unit, rather than at the rear. All input and (tape-out) terminals, as well as AM and FM antenna terminals, can be reached from the right side of the unit, while two sets of spring-loaded speaker terminals, preamplifier-output/main amplifier-input terminals and a switch that separates the two major receiver sections electrically are located on the opposite side panel (see Fig. 2). A cleverly designed channel along each side of the unit keeps cables neatly tucked out of sight. This innovative arrangement makes installation extremely simple, especially for a large, heavy unit such as this one, which might be difficult to hook up if all connections had to be made at the rear panel.

No schematic diagram was supplied with our sample test unit, but it is clear from the receiver's internal layout (shown in Fig. 3) that

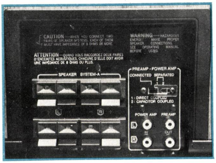
MANUFACTURER'S PUBLISHED SPECIFICATIONS:

FM TUNER:
Usable Sensitivity: mono, 8.7 dBf (1.5 μV); stereo, 15 dBf. **50-dB Quieting:** mono, 12.5 dBf; stereo, 34.0 dBf. **S/N Ratio:** mono, 80 dB; stereo, 76 dB. **Harmonic Distortion** (wide): mono, 0.06% at 1 kHz and 100 Hz; 0.08% at 6 kHz; stereo, 0.1% at 100 Hz and 6 kHz, 0.08% at 1 kHz. **Selectivity:** 90 dB (narrow); 55 dB (wide). **Capture Ratio:** 0.9 dB. **Image, IF and Spurious Rejection:** 110 dB. **Frequency Response:** 30 Hz to 15 kHz, +0.2, −1.0 dB. **Stereo Separation:** 50 dB at 1 kHz; 40 dB at 100 Hz and 10 kHz.

AM TUNER:
Usable Sensitivity: 300 μV/M internal antenna. **Selectivity:** 30 dB. **S/N Ratio:** 50 dB. **Distortion:** 0.45%. **Image and IF Rejection:** 70 dB.

AMPLIFIER:
Power Output: 160 watts-per-channel into 4 or 8 ohms, 20 Hz to 20 kHz at no more than 0.03% total harmonic distortion. **IM Distortion:** 0.03%. **Damping Factor:** 60. **Frequency Response:** power amplifier section, DC to 200 kHz, +0, −3 dB; overall, auxiliary inputs, 5 Hz to 50 kHz, +0.2, −1.5 dB; phono, RIAA ±0.2 dB. **Input Sensitivity:** phono 1 & 2, 2.5 mV; high level, 150 mV; mike, 6.0 mV. **S/N Ratio:** phono, 78 dB ("A" weighted); high level, 95 dB. **Bass Control Range** (400-Hz turnover): ± 10 dB at 50 Hz. **Treble Control Range** (1.5 kHz turnover): ± 10 dB at 10 kHz. **Mid-Range:** ±5 dB at 1.5 kHz. **Subsonic Filter:** −3 dB at 16 Hz (6 dB-per-octave). **High-cut filter:** −3 dB at 3 kHz (6 dB-per-octave).

GENERAL SPECIFICATIONS:
Rated Power Consumption: 680 watts. **Dimensions:** 22 1/16 W × 8 H × 19 1/2 inches D. **Net Weight:** 59.3 lb. **Suggested Retail Price:** $1050.



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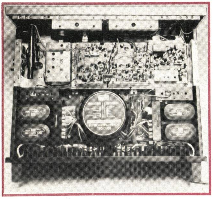
the huge toroidally wound power transformer has two separate secondary windings, each of which supplies power to a single channel; voltages are filtered separately by two pairs of large filter capacitors.



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The power amplifier, as mentioned earlier, is a DC-coupled circuit from input to output, with no capacitors either in the signal path or in the overall negative-feedback loop. If components are connected directly to the main amplifier (by separating the preamplifier and main amplifier sections electrically), and if the outputs of those components contain any DC signal, the protection circuit immediately disconnects the speakers from the output stages. In that event, the switch separating the preamplifier output from the main-amplifier input has a third setting that introduces an input capacitor so that operation can be resumed.

FM measurements

Table 1 summarizes FM measurements made for the *model G-9000*. Where measurements differ between the wideband and narrowband positions, both sets of measurements are shown separated by a slash (/). For example, while 1-kHz mono distortion measured an incredibly low 0.03% in mono using the preferred wideband setting, when using the narrowband setting (used only if adjacent-channel interference is encountered in crowded FM listening areas), distortion increased to 0.15%.

Sansui evidently decided to make the narrowband IF response very narrow indeed because distortion rises markedly when this setting is used, particularly in the stereo mode. Wideband distortion readings, on the other hand, are among the lowest we've ever encountered for an FM tuner section or, for that matter, for a separate component tuner.

Separation capability of the *model G-9000* also varies depending upon whether the narrow or wideband settings are used. Figure 4 shows the frequency response of the left channel as well as crosstalk in the opposite channel (lower trace). The vertical scale is 10 dB-per-division, and we measured static separation of nearly 50

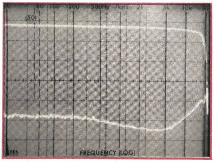

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TABLE 1
RADIO-ELECTRONICS PRODUCT TEST REPORT

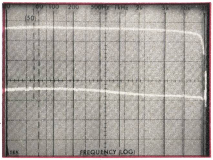
Manufacturer: **Sansui** Model: **G-9000**

FM PERFORMANCE MEASUREMENTS

SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	**R-E Measurement**	**R-E Evaluation**
IHF sensitivity, mono (μV) (dBf)	1.5 (8.7)	**Superb**
Sensitivity, stereo (μV)	5.5 (20.0)	**Very good**
50-dB quieting signal, mono (μV)	1.5 (8.7)	**Superb**
50-dB quieting signal, stereo (μV)	18 (30.3)	**Superb**
Maximum S/N radio, mono (dB)	80	**Excellent**
Maximum S/N ratio, stereo (dB)	76	**Excellent**
Capture ratio (dB)	1.0	**Excellent**
AM suppression (dB)	65	**Excellent**
Image rejection (dB)	100+	**Superb**
IF rejection (dB)	100+	**Superb**
Spurious rejection (dB)	100+	**Superb**
Alternate channel selectivity (dB)	92/53	**Excellent**
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (±dB)	+0, −1.5	**Good**
Harmonic distortion, 1 kHz, mono (%)	0.03/0.15	**Superb**
Harmonic distortion, 1 kHz, stereo (%)	0.06/0.5	**Superb/see text**
Harmonic distortion, 100 Hz, mono (%)	0.06/0.07	**Superb**
Harmonic distortion, 100 Hz, stereo (%)	0.09/0.7	**Superb/see text**
Harmonic distortion, 6 kHz, mono (%)	0.06/0.13	**Superb**
Harmonic distortion, 6 kHz, stereo (%)	0.10/0.45	**Excellent**
Distortion at 50-dB quieting, mono (%)	3.0/5.0	**See text**
Distortion at 50-dB quieting, stereo (%)	0.8/0.6	**Good**
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) (dBf)	3.0 (14.8)	**Very good**
Separation, 1 kHz (dB)	48/36	**Excellent**
Separation, 100 Hz (dB)	43/34	**Very good**
Separation, 10 kHz (dB)	42/30	**Excellent**
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	4.5 (18.3)	**Very good**
Dial calibration accuracy (±kHz at MHz)	Perfect	**Superb**
EVALUATION OF CONTROLS, DESIGN, AND CONSTRUCTION		
Control layout		**Excellent**
Ease of tuning		**Very good**
Accuracy of meters or other tuning aids		**Superb**
Usefulness of other controls		**Good**
Construction and internal layout		**Excellent**
Ease of servicing		**Good**
Evaluation of extra features, if any		**Very good**
OVERALL FM PERFORMANCE RATING		**Excellent**

dB at mid-frequencies.

Note that our test equipment is now equipped to provide flat frequency-response readings (compared with the response readings shown in previous test reports that include the de-emphasis characteristics of the tuner) so the



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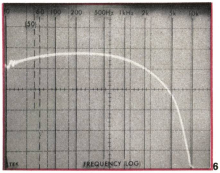
scope traces represent actual response.

When the narrowband setting is used, separation is somewhat diminished, as shown in Fig. 5, although overall frequency response remains unaltered and quite good.

In recent months, we have received requests to report on the AM sections of the tuners and receivers we test. While the harmonic distortion and signal-to-noise ratio measured for the AM section of the *model G-9000* were both within specifications, the AM frequency response (not specified by Sansui) was as poor as it is on most "hi-fi" receivers. To demonstrate this, we swept modulating frequencies much as we do for FM response measurements; the results (although hard to believe) are shown in the scope photo of Fig. 6. Perhaps Sansui and other manufacturers will pay more attention to



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their AM bandwidth if and when stereo AM becomes a reality in the near future. For the moment, the less said about AM response in typical high-fidelity receivers and tuners the better.

peak-to-peak swing of 96 volts is possible under full-load conditions. This corresponds to an RMS AC value of 33.94 volts (peak-to-peak value divided by 2.828, or multiplied by 0.5 × 0.707). The continuous power output of this first amplifier, before clipping, would be approximately 144 watts. ($P = E^2/Z$, where $E = 33.94$ volts and Z, the impedance, is assumed to be 8 ohms.)

Now let's calculate the continuous power output for the amplifier being powered by the supply shown in Fig. 2, where the available supply voltage has dropped to plus and minus 40 volts. The permissible peak-to-peak swing of the output signal voltage is 80 volts. This corresponds to an RMS value of only 28.29 volts, or an equivalent power across 8 ohm loads of 100.03 watts.

Thus we see that even though both power supplies (under no-load conditions) provide the same operating voltages to their associated amplifiers under no-signal (or low-signal) conditions, their maximum continuous power output ratings will differ substantially, with the amplifier powered by the supply shown in Fig. 2 able to deliver only 69% as much continuous power as the amplifier powered by the supply shown in Fig. 1.

Power supply regulation

There are several reasons why the voltage output of the supply shown in Fig. 2 dropped more quickly than the voltage delivered by the supply shown in Fig. 1. For one thing, its filter capacitors are of considerably lower value. The primary filter capacitors in such a supply act as a power or energy reservoir. The greater their value, the greater the amount of energy that can be stored in them. Note, too, that the primary and secondary windings of each of the power transformers used in the two supplies may have different internal resistances and, therefore, different AC voltage drops may appear across these windings before the AC voltages are ever rectified. The bridge rectifiers, too, may differ in internal resistance and may therefore develop greater voltage drops across their terminals as the current demand increases.

Short-term signals

If we were to apply a very short signal burst to each of the amplifiers associated with the power supplies, the situation would be quite different. If the signal burst were short enough, the filter capacitors would maintain their full (or nearly their full) charge for the duration of the short pulse and the available voltage at the power output stages of each amplifier would be very close to the no-load value of plus and minus 50 volts. Under these circumstances, each amplifier would be able to provide a peak-to-peak signal swing of 100 volts, which would correspond to a short-term power output of 156.3 watts!

These short-term musical signals are exactly what an amplifier is called upon to reproduce when it is hooked up to speakers and fed with program sources in a "real-world" high-fidelity system. No one (at least no one we know of) spends much time listening to continuous sinewave test signals. Yet, if we were to be guided by the continuous power ratings of the two amplifiers used in our example, one would have a rating of just over 100 watts-per-channel while the other would be rated at 144 watts-per-channel. In auditioning these two amplifiers you might well conclude that the 100-watt unit (which would undoubtedly sell for less money than the higher powered model) "sounds" just as loud as the higher powered unit before audible clipping takes place.

At the present time, the Institute of High Fidelity is completing its work on a new amplifier measurement standard. One of the most important new measurements that is being incorporated in this new standard has been given the tentative name, Dynamic Headroom. This measurement seeks to take into account the wide discrepancies that may occur between the continuous power ratings of amplifiers and their ability to deliver power over the short terms typically required during music signal reproduction. In order to simulate these short-term conditions, studies were conducted by the IHF committee regarding the actual duty-cycle and power distribution of musical signals. A test signal was arrived at which, it is felt, approximates what an amplifier must be able to handle when reproducing typical music signals. This new test signal is shown in Fig. 3. It consists of a 1-kHz signal which is at an

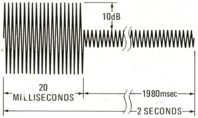


FIG. 3—NEW TEST SIGNAL for determining dynamic headroom of an amplifier. Signal consists of 1-kHz sinewaves with a 10 dB amplitude change.

arbitrary level for 20 milliseconds (twenty cycles of this signal will therefore appear) and the same frequency at an amplitude 10 dB lower for another 1980 milliseconds. This complex signal is repeated, therefore, every two seconds. A portion of the test signal is shown in the scope photo of Fig. 4.

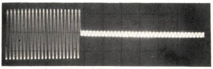


FIG. 4—NEW TEST SIGNAL as it would appear on an oscilloscope.

We decided to use this new test signal to check out the Dynamic Headroom of an amplifier which happened to be in our lab at the time this article was being written. The amplifier had a continuous power output rating of 25 watts-per-channel. To confirm this, we first ran a continuous test signal into the amplifier and adjusted our scope display so that one vertical division equalled 10 volts peak-to-peak. We reached clipping when the amplitude of the sinewaves reached 40 volts (4 divisions), as shown in Fig. 5. This corre-

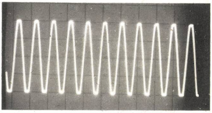


FIG. 5—CONTINUOUS POWER OUTPUT can be determined by determining the input level required to drive an amplifier into clipping with a 1-kHz input signal.

sponded to an RMS value of 14.14 volts, or just over 25 watts across an 8 ohm load.

Next, we applied a signal similar to that shown in Figs. 3 and 4. The oscilloscope's sweep rate was increased so that we might be able to examine the crests of the sinewaves during the 20-millisecond duration of the higher amplitude pulses.

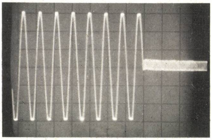


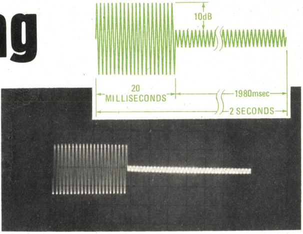
FIG. 6—OUTPUT OF AMPLIFIER that is being driven just to the point of clipping by new test signal.

Again, the gain was increased until evidence of clipping appeared, without changing the vertical sensitivity of the scope input. The results are shown in Fig. 6. Using our new test signal, the peak-to-peak amplitude of the sinewaves reached 60 volts. This corresponds to an RMS value of 21.22 volts, or a short-term power output capability of 56.27 watts!

Specifying dynamic headroom

The IHF Amplifier Standards Committee was faced with the problem of how best to specify the new measurement results. They could, of course, simply list a second power rating and call it "dynamic power." If that were to be done, however, the Federal Trade Commission requires that such a "secondary" power rating must be printed in the spec sheets (or in any advertising material) using

Understanding Dynamic Headroom



Dynamic headroom, a new addition to the Institute of High Fidelity amplifier measurement standards. Tells why amplifiers with the same rated power may perform differently under varying signal levels.

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

EVER SINCE THE FEDERAL TRADE COMMISsion issued its rule regarding disclosure of the power output ratings of audio amplifiers, manufacturers of high-fidelity amplifiers and receivers have been faced with a mixed blessing. On the one hand, the requirement that amplifier makers list the continuous power rating of their amplifiers has forced less-than-honest manufacturers to abandon such meaningless power output terms as "peak power," "instantaneous peak power," "music power," "dynamic music power" and more. The continuous power rating, coupled with a statement of load impedance, power bandwidth (the frequency extremes over which the product will actually deliver its rated power) and harmonic distortion has enabled prospective buyers of audio amplifiers to compare brands and models on a reasonably equal basis. This uniformity of specifications is all to the good.

On the other hand, it didn't take the experts long to conclude that two amplifiers that have exactly the same continuous power output rating (including the same power bandwidth and even the same rated harmonic distortion) may not necessarily deliver the same program *loudness* to identical speaker systems when fed with actual program signals. Obviously, to properly define the useful power output capability of an amplifier, more information is needed than the simple statement of "continuous power output" capability.

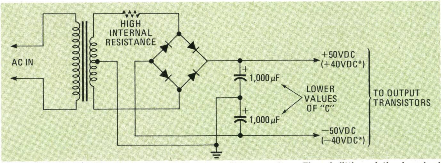


FIG. 1—POWER SUPPLY for hi-fi amplifier has large filter capacitors. There is little variation in output voltage between no-load and full-load conditions.

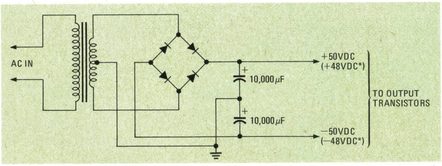


FIG. 2—POWER SUPPLY for hi-fi amplifier has small filter capacitors and a high internal resistance in either the transformer or bridge rectifiers. This supply delivers an output voltage with a wide variation between no-load and full-load conditions.

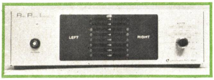
Power supply reserve

The reason for this can be found by examining the two power supply diagrams of Figs. 1 and 2. Note that both supplies have nominal output voltages of plus and minus 50 volts under no-load (no-signal) conditions. The alternate voltages (designated with an asterisk) are those that are present when the amplifier is delivering a large amount of current to the speaker loads. Under a full-load condition, the power supply shown in Fig. 1 delivers plus and minus 48 volts, while the power supply shown in Fig. 2 delivers a much lower output of only plus and minus 40 volts. What does this mean in terms of continuous power output capability?

Assuming that the output signal can swing over the entire peak-to-peak value of the power supply voltage, we see that in the case of the power supply of Fig. 1, a

Lectrotech Model PPI-400 Peak Power Indicator

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR



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CIRCLE 105 ON FREE INFORMATION CARD

THE LECTROTECH *MODEL PPI-400* PEAK-POWER indicator is an accessory device intended for connection either to the amplifier output terminals or to the speaker terminals of a high-fidelity component system. It indicates instantaneous peak-power output from a stereo amplifier by means of flashing LED's, each calibrated to light at a different input voltage to the unit.

The front panel of the *model PPI-400* is shown in Fig. 1. The left side of the panel contains a pushbutton POWER on/off switch. The dark-colored center of the panel contains two vertical rows of LED's, calibrated from 0 dB at the top to −30 dB for the lowest indicator in each row. The bottom four LED's in each row are green, the next pair are yellow and the top two LED's in each row are red.

A selector switch on the right-hand side of the panel selects the sensitivity range of the indicators, as related to the nominal impedance of the speakers being used. For 4-ohm speakers, the six calibrated switch settings provide a power range (for 0-dB indications) from 25 watts to 600 watts-per-channel. For 8-ohm speakers, the ranges are from 12.5 watts to 400 watts; whereas for 16-ohm speakers, the power ranges from 6.25 watts to 200 watts. This arrangement demonstrates that the unit actually responds to input *voltage* rather than to true power input and, therefore, will not take into account any variations in speaker impedance with frequency. The device, therefore, displays errors depending upon a speaker's departure from nominal impedance at different audio frequencies.

A seventh selector switch setting permits you to calibrate the instrument to any desired 0-dB reference level other than those already provided. This switch position, labeled AUX on the panel, is calibrated by installing two appropriate resistors across two sets of terminals at the left of the rear panel that come supplied with jumpers. The jumpers are removed and resistors are substituted. You select the resistors in accordance with the formula, $R = 2\sqrt{PZ} - 10$, where P is the desired power for 0-dB reference, Z is the loudspeaker impedance and R is the required resistor, in 1000 ohms.

This additional switch position makes it possible to calibrate and use the instrument with two monophonic amplifiers (for example, musical instrument amplifiers) even if the power-output rating of each amplifier is different (two different resistance values can be used).

TABLE 1

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Lectrotech** Model: **PPI-400**

OVERALL PRODUCT ANALYSIS

Retail price	**$129.95**
Price category	**Medium**
Price/performance ratio	**Fair**
Styling and appearance	**Good**
Sound quality	**N/A**
Mechanical performance	**Good**

Comments: Certainly this accessory device does what it is supposed to do with a fair degree of accuracy. It provides an approximate indication of instantaneous peak-power output from a stereo audio amplifier. The LED indicators do not suddenly light up or go out. Rather, there is a transitional region for each LED that spans between 2 dB and 3 dB. You must decide subjectively when a given LED is really lit. A vague area of indication that is 3 dB in amplitude represents a power difference of 2:1—which can be trying when you are judging whether or not your amplifier is going into clipping or not!

In addition, by just adding a bit more circuitry and switching, the *model PPI-400* could have been made to read *voltages* that are typical of those applied to tape-deck inputs. Thus, the unit could have served as a peak indicator to augment most cassette or open-reel tape-deck VU meters. We are told by the people at Lectrotech that such a dual-purpose unit is evidently planned, but it will undoubtedly cost more than the single-purpose *model PPI-400* we tested. Presently, the minimum sensitivity of 3.13 mW across 8 ohms is equivalent to 0.16 volt, somewhat more than is usually available at the record-out jacks of most amplifiers or receivers, and greater than the amount of drive usually required by most tape-deck line inputs.

If you want to know approximately how much power you are feeding to your loudspeakers at all times, the *model PPI-400* will serve that purpose, and if your hi-fi component system is fairly expensive and lacks peak-power indication, the added cost of a device such as the *model PPI-400* may not seem unreasonable—especially if it prevents speaker burnout even once in the life of your stereo system.

Measurement and use tests

To test the *model PPI-400* we hooked up a suitable amplifier with which to evaluate the unit.

Since the device is most useful in measuring short-term or instantaneous power, we used a variety of tone bursts to determine whether the LED's respond quickly enough to music-like transients. Specifically, we used the new test signal required in the dynamic headroom test of the recent IHF Amplifier Measurement Standards (IHF-A-202). This signal consists of 20 ms of a 1-kHz test tone at full amplitude, followed by 480 ms of the same test frequency reduced by 20 dB. The signal's repetition rate is twice per second. Under these test conditions, a standard output meter reads approximately 12 dB below the full-amplitude value of the signal, while the LED's continued to read correct peak instantaneous power.

It was somewhat difficult to judge the accuracy of the device since individual LED's do not light up completely when triggered, but start dimly and then with increased signal amplitude, begin lighting up fully. The change in amplitude of applied voltage between the barely visible illumination of an LED and the full brightness of the same LED ranged from about 2 dB to 3 dB. It is possible, of course, to calibrate the *model PPI-400* so that when the LED's are either barely lit or fully bright, this corresponds to the desired power level, but some eyeball judgment is necessary.

Summary

Our overall product evaluation, together with a summary of its usefulness, is shown in Table 1. The *model PPI-400* is not a precision instrument, but then it is not very expensive for a device of this type. It could prove useful if you own an amplifier with higher power-output capabilities than your speakers can handle. Setting the 0-dB calibration point for the speakers' maximum power-handling value could protect the speakers against possible overdrive damage. **R-E**

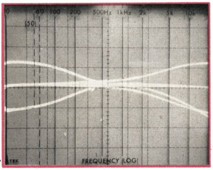
MANUFACTURER'S PUBLISHED SPECIFICATIONS:

Input Impedance: 20,000 ohms, minimum. **Accuracy:** ±0.25 dB. **Frequency Response:** 20 Hz to greater than 20 kHz. **Maximum Input Power:** 1250 watts continuous at 8 ohms. **Minimum Input Sensitivity:** 3.13 mW at 8 ohms. **Loudspeaker Impedance Range:** 2 to 35 ohms. **Power Range and Impedance Combinations:** 18 plus auxiliary. **Dimensions:** 14 W × 3¾ H × 8 inches D. **Weight:** 3½ lb. **Power Requirements:** 105 to 125 V, 50 to 60 Hz, 7 watts. **Suggested Retail Price:** $129.95 (optional walnut cabinet, $24.95 extra).

Amplifier measurements

Table 2 lists amplifier measurements made on the *model G-9000*. The amplifier delivered more than its rated output at all frequencies before significant distortion was observed. The reason for the two power readings at 20 kHz (into 8-ohm loads) in Table 2 is because we were uncertain whether Sansui wishes to rate distortion at 0.02% or 0.03% (rather an academic point, since neither level of harmonic distortion would be audible). In any event, if the figure is 0.03%, the amplifier delivers greater than its 160-watt rating even at the 20-kHz extreme; if 0.02% is really the rated specification, it falls a bit short of the 160-watt mark at the high-frequency extreme.

We were pleased to find variable turnover tone controls on this high-powered, high-quality stereo receiver because the user then has much greater tone control capability. The range of tone controls using inner 400-Hz and 2.5-kHz turnovers is shown in Fig. 7, along



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with the high-cut filter action. This filter, with its very moderate slope, clearly offers no advantages over treble-cut filters since the two curves almost coincide. Sansui could have provided a steeper slope (12 dB-per-octave) or at least raised the cutoff frequency of their high-cut filter.

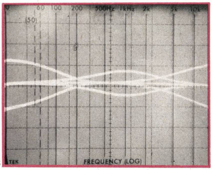

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Figure 8 shows the bass and treble control range when the 200-Hz and 5-kHz turnover points are selected. Superimposed on these curves is the mid-range tone control range whose well-centered frequency provides the type of presence control action expected of it.

The loudness compensation circuit at various listening levels has a fairly typical response.

Summary

Table 3 contains our overall product evaluation along with our summary comments. We believe the Sansui *model G-9000* represents the most advanced circuit design yet seen in all-in-one receivers, and, considering what separate components offering the same quality, power and flexibility can cost, turns out to be very fairly priced. **R-E**

TABLE 2
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Sansui** — Model: **G-9000**

AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
POWER OUTPUT CAPABILITY		
RMS power/channel, 8-ohms, 1 kHz (watts)	174.8	**Excellent**
RMS power/channel, 8-ohms, 20 Hz (watts)	169.3	**Excellent**
RMS power/channel, 8-ohms, 20 kHz (watts)	158.0/162.0	**See text**
RMS power/channel, 4-ohms, 1 kHz (watts)	256.0	**Excellent**
RMS power/channel, 4-ohms, 20 Hz (watts)	232.0	**Excellent**
RMS power/channel, 4-ohms, 20 kHz (watts)	203.0	**Very good**
Frequency limits for rated output (Hz-kHz)	10-30	**Good**
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.006	**Superb**
Intermodulation distortion, rated output (%)	0.009	**Superb**
Harmonic distortion at 1-watt output, 1 kHz (%)	0.018	**Very good**
Intermodulation distortion at 1-watt output (%)	0.025	**Excellent**
DAMPING FACTOR, AT 8 OHMS	100	**Excellent**
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ±dB)	+0,−0.5	**Very good**
Maximum input before overload (mV)	340	**Superb**
Hum/noise referred to full output (dB) (at rated input sensitivity)	78 ("A" weighted)	**Excellent**
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ±dB)	3-80, 3.0	**Superb**
Hum/noise referred to full output (dB)	93	**Superb**
Residual hum/noise (minimum volume) (dB)	102	**Excellent**
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 7	**Excellent**
Action of secondary tone controls	See Fig. 8	**Excellent**
Action of low-frequency filter(s)		**Excellent**
Action of high-frequency filter(s)	See Fig. 8	**Fair**
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	2.5/2.5	
Input sensitivity, auxiliary input(s) (mV)	150	
Input sensitivity, tape input(s) (mV)	150	
Output level, tape output(s) (mV)	150	
Output level, headphone jack(s) (V or mW)	100 mW	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		**Excellent**
Adequacy of input facilities		**Excellent**
Arrangement of controls (panel layout)		**Excellent**
Action of controls and switches		**Excellent**
Design and construction		**Very good**
Ease of servicing		**Good**
OVERALL AMPLIFIER PERFORMANCE RATING		**Excellent**

TABLE 3
OVERALL PRODUCT ANALYSIS

Retail price	**$1050**
Price category	**High**
Price/performance ratio	**Excellent**
Styling and appearance	**Very good**
Sound quality	**Superb**
Mechanical performance	**Very good**

Comments: If ever a manufacturer could boast that a receiver offers all the features and performance of high-priced separate components, Sansui has certainly earned that right with their *model G-9000.* The DC-amplifier configuration of the power section provides sound quality as good as any we have heard from the most sophisticated separate power amplifiers. To judge this quality, in our listening tests we used several mint-condition direct-to-disc recordings.

As for control flexibility, the *model G-9000* has it all; so much, in fact, that the front panel may seem somewhat intimidating on first use. Soon, however, the logical front-panel arrangement becomes familiar, and easy to use and enjoy.

Sansui was among the first to offer variable IF bandwidth for FM in a tuner, and they have extended that feature into this receiver. We found, however, that while the wide setting offers about the lowest distortion FM we've ever measured, the narrow position (useful when stations are very close together on the dial) is almost *too* narrow and should be avoided unless there is just no alternative for a desired incoming signal.

The well-calibrated power-output meters should insure against inadvertent overload and clipping, although that is hardly likely to happen because of the receiver's high power-output capability. Since many otherwise excellent speakers cannot handle the full power output of this receiver, prospective users are urged to check out the maximum power-handling capacity of the speakers they intend to use with it. The *model G-9000* is truly one of the best "component" systems we have ever checked.

letters that are no greater than two-thirds the size of the letters used to specify the continuous power rating. In addition, the appearance of an alternate power rating in watts might, in time, lead to the same sort of confusion that arose years ago and that prompted the Federal Trade Commission to promulgate the power rule for audio amplifiers in the first place.

The committee therefore decided that Dynamic Headroom should be specified in terms of decibels *above* the rated continuous power. Not only does this get around the problem of having multiple (and confusing) wattage listings for the same amplifier, but it serves to give the potential purchaser some idea as to how much louder the amplifier will sound when reproducing music signals as compared with its ability to reproduce a continuous sinewave test tone.

In the example just taken from our actual measurements in the lab, since the short-term power was 56.27 watts and the continuous power rating was 25 watts, the ratio of those two numbers is 2.25, which translates to a Dynamic Headroom of 3.52 dB. Based upon our experience with a variety of amplifiers, that degree of Dynamic Headroom is very great indeed. Generally, you can expect the Dynamic Headroom of typical audio amplifiers to range from 0 dB to around 3.0 dB. A Dynamic Headroom of 0 dB would mean that the amplifier has a very stiff power supply—one whose voltage does not vary at all from "no-signal" to full-signal conditions. An amplifier with a Dynamic Headroom of 3 dB would be one with a very "soft" or poorly regulated power supply whose voltage drops by a factor of approximately 30% when full current is delivered to the load.

Checking dynamic headroom

You can check the dynamic headroom of your own amplifier or receiver even if you lack the test equipment needed to produce the special signal we have described. All you need is an accurately calibrated oscilloscope and an audio oscillator which can apply a single-tone 1-kHz signal to the high level inputs of your equipment. First, determine the amplitude of a 1-kHz output signal that causes the amplifier to barely clip. Record the amplitude in peak-to-peak volts, as observed on the scope. Then, apply a music signal to the set (either from a recording or from an FM tuner) and observe the new clipping level, which should be somewhat greater than that obtained during the first sinewave test. Even if your scope is not calibrated, you can still determine the Dynamic Headroom of your equipment quite accurately, in dB. For example, we used still another amplifier and, without regard to its continuous power rating, we applied a 1-kHz test tone until clipping occurred. We set the sensitivity of the vertical amplifier of the scope so that this amplitude occupied four divisions, vertically (see Fig. 7). Then, applying a music signal to the amplifier, we noted that at clipping, the vertical amplitude was 4.6 vertical divisions on the scope (positive peaks were about 3/10ths of a division higher than before, and so were negative clipped peaks). These results are shown in the scope photo of Fig. 8. To calculate the Dynamic Headroom of this amplifier, divide 4.6 by 4.0 to obtain a voltage ratio of 1.15. This corresponds to a dB difference of 1.21. So, the Dynamic Headroom of this amplifier is 1.21 dB.

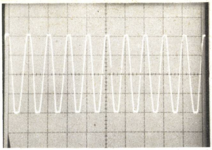


FIG. 7—AMPLIFIER'S DYNAMIC HEADROOM can be obtained by first determining the input level required to drive the amplifier into clipping with a 1-kHz input signal.

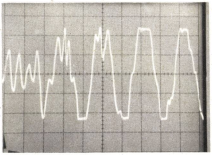


FIG. 8—CLIPPING LEVEL of program material is used to determine amplifier's dynamic headroom.

The concept of Dynamic Headroom is just one of the new measurement ideas which will be incorporated in the new IHF Amplifier Measurement Standards, but it is one which should help to clarify one of the seeming discrepancies which still exists when comparing the performance of similarly power-rated audio products that, under actual use, "sound different." As soon as the members of the IHF approve of the entire new standard, we will detail the other important measurement techniques incorporated in that standard in a future article. **R-E**

Pioneer Electronics receives award for contribution to arts

U.S. Pioneer Electronics, a leading audio component manufacturer, was a first-time winner this year in the 12th annual "Business in the Arts" awards program, co-sponsored by *Forbes* magazine and the Business Committee for the Arts, a national organization that promotes greater business and industry involvement in the arts. The award this year was an original print by American artist Romare Bearden.

Pioneer was awarded its prize for a national campaign to raise funds for the Metropolitan Opera. Not only did the company match every dollar contributed by the general public and authorized Pioneer dealers, but obtained matching funds from the National Endowment for the Arts; this helped quadruple the original public donations. The company footed the bill for all advertising and promotional campaigns. A quarter of a million dollars was raised for the Met.

Electronic town meeting via 2-way cable TV

Upper Arlington, OH, a suburb of Columbus, recently experienced its first electronic "town meeting of the air." This was made possible by Warner Cable's participatory two-way cable QUBE system, which allows viewers to express their opinions on the air on matters of public interest, such as municipal services, public utilities, etc., in their areas.

Here's how QUBE works: Town officials, broadcasting live from QUBE's TV studios, posed questions to which viewers responded by pressing a button on their home terminals, registering their opinions or criticisms. The results were then tabulated by a computer for display on home TV screens. A special hookup to the QUBE studios also made it possible for participants to phone in their own questions to the town officials. Random numbers were assigned so that no individual home was known or identified with the opinions expressed.

National satellite network transmits public service programs

This past September, the Public Service Satellite Consortium (PSSC) used Denver, CO, as the "launch site" of a new continuing education program transmitted via a communications satellite. This transmission was a pilot demonstration of the non-broadcast use of the public television satellite system.

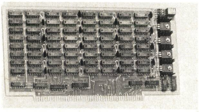
The program was a special education presentation created for members of the American Dietetic Association who viewed it at more than 100 selected locations in eight major cities across the U.S. Pretaped portions of the program were linked up with a panel of experts in Denver, and the dieticians viewing it on screens in auditoriums, schools and hospitals could question the experts via telephone.

The signal was beamed to Western Union's communications satellite Westar I, which then retransmitted it to public television stations in Anchorage, AK, San Diego, Indianapolis, Las Vegas, Columbus, OH, Cleveland, OH, Columbia SC and Spokane, WA.

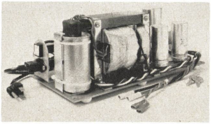
According to the PSSC, this new satellite system will connect all PBS stations by the end of 1978. Because the system allows each station to receive up to four transmission simultaneously, this will allow PBS to transmit nonbroadcast programs for its members, more than 100 nonprofit organizations and other nonprofit groups. The system is expected to be operative by early 1979. **R-E**

ALL ABOUT

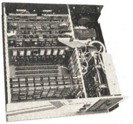
Hobby Computer



STATIC RAM MEMORY from Vector Graphic is designed for the S-100 bus structure. Four Motorola MC7805CP 3-terminal voltatge-regulator iC's are along the right-hand edge.



TYPICAL POWER SUPPLY for hobby computers has heavy power transformer and computer-grade electolytic filter capacitors. The voltage regulators are mounted on the motherboard.



VECTOR model 1+ microcomputer has power supply along right side of cabinet. Cooling fan in right rear corner exhausts hot air.

The power supply is perhaps one of the most critical of a
often used in microcomputer circuitry, operate from a DC suppl
be allowed to go above 5.6. This is the story of high-current powe

MICROCOMPUTERS BUILT WITH THE S-100 BUS USE DISTRIBUTED regulation to supply +5 volts DC to the various circuits. Distributed regulation uses one or more three-terminal IC regulators (i.e., LM309, 7805, LM340-5) mounted on each printed circuit board. The main high-current power bus on the S-100 motherboard is unregulated +8 volts DC.

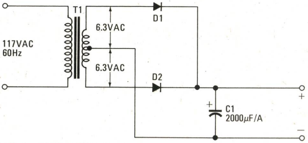


FIG. 1—SIMPLE FULL-WAVE RECTIFIER uses two diodes and a center-tapped transformer.

But certain other mainframes use +5 volts DC *regulated* on the main power distribution bus, and obtaining that type of supply at a reasonable cost is quite a chore! At current levels of around 5 amperes, you cannot use a simple three-terminal IC regulator. Finding a series-pass transistor able to handle the load current and possessing a *beta* high enough to allow use of the simple Zener-controlled base circuit type of regulator is almost

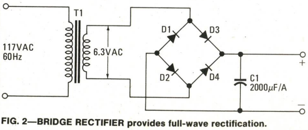


FIG. 2—BRIDGE RECTIFIER provides full-wave rectification.

impossible. In this article we will discuss several approaches to solving the problem of high-current supplies.

Pseudo-distributed system

The microcomputer kit I purchased recently uses a motherboard with the +5 volt DC and ground foil traces connected to the individual card-edge connectors. The total current demand of a fully populated motherboard is approximately 16 amperes. In trying to develop a power supply, one solution I tried with moderate success was to cut the +5-volt foil trace on the motherboard at strategic points, and then mount external three-terminal IC regulators nearby. One regulator served each section of the board. The three types mentioned earlier are suitable for current drains of 1 ampere in the TO-3 case, and 750 mA in the plastic case. The LM323 will handle 3 amperes, and the Lambda LAS-1905 will handle 5 amperes.

The pseudo-distributed system works well, but is sloppy. In some cases, this approach is made more difficult by the fact that not all motherboards are laid out in the nice straight lines of the S-100 bus! The +5-volt DC line may wander, breaking off at points, and then rejoining later on. These difficulties often force us to look at other alternatives.

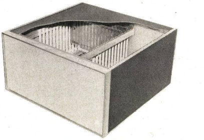
Rectifiers and filters

In the regulator circuits to follow we will show only the regulator and associated circuitry, since this is where the main problem in design is. All these circuits will be preceded by a rectifier and filter circuit such as those shown in Figs. 1 and 2.

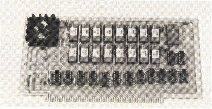
Both of the circuits shown in Figs. 1 and 2 are full-wave rectifiers, meaning that they make use of both alternations of the AC sinewave from the power mains. This type of rectifier is not only easier to filter (the traditional justification) but also results in a higher average DC output voltage, and requires less power (i.e., V × A) from the transformer primary for any given load current.

The rectifier circuit in Fig. 1 uses two solid-state diodes and a center-tapped transformer. The center tap is taken as the

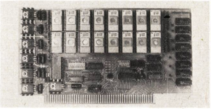
Power Supplies



VECTOR'S VP2 ENCLOSURE permits you to design and house your own microcomputer. Card-guides are provided. Power supply can be installed in smaller compartment.



RAM MEMORY BOARD from Electronic Control Technology mates with S-100 bus. Type LM340T regulator IC's are on massive heat-sink in upper left corner.



COMBINATION RAM AND ROM memory board is designed for S-100 bus configuration. Distributed voltage regulation uses six 3-terminal voltage-regulator IC's.

obby computer components. TTL (Transistor-Transistor Logic) IC's, with a nominal level of 5 volts and a maximum level that must not supply regulation and how you can design and build your own supply.

JOSEPH J. CARR

common (or ground) terminal, while the positive output is taken from the junction of the two diode cathodes. The alternate circuit, shown in Fig. 2, is a bridge rectifier that can be made from four discrete diodes, or be purchased as a prepackaged bridge.

Almost all voltage regulator circuits require a DC input that is at least 2.5 volts higher than the rated output voltage. In our case, with +5-volts DC output, the DC input voltage should be not less than +7.5. In case you have wondered, this is probably the reason why Altair, the original S-100 bus designers, specified +8 volts for the main power bus. An ordinary 6.3-volt AC (RMS) filament transformer will deliver this potential when full-wave rectified and filtered. The filter will charge to $1.4 \times E_{RMS}$, which in this case is $1.4 \times 6.3 = 8.8$ volts. In most cases, a 6.3-volt high-current filament transformer is sufficient.

The standard 6.3-volt filament transformer is a good choice for use in a circuit such as Fig. 2 because the bridge rectifier uses the entire secondary. Keep in mind, however, that the *transformer can deliver only half its rated current in the bridge configuration.* In the case of Fig. 1, a 12.6-volt transformer will provide 6.3 volts AC either side of the center tap, so it is a good choice. It will deliver the same output potential as the bridge rectifier used with a 6.3-volt transformer, and will supply its rated current.

Fortunately, 6.3 and 12.6 volts AC are the filament ratings of many high-power transmitting tubes used in commercial and military transmitters. Many such transformers are still available on the surplus market, although the supply is down from its heights of only a few years ago. You should be able to save a considerable amount of money by checking the local electronic surplus outlets, ham friends (who tend to save such items), or by attending hamfests and auctions. If a push comes to a shove, or you have money to spend, then go to your local parts distributor and buy a new transformer outright. I have used several Triad types that are particularly useful because their tapped primary offers secondary AC voltages of either 6.3 or 7.5. Table 1 gives the type numbers and ratings.

The rectifier diodes or bridge-rectifier stacks should be rated to handle more current than is expected at full load, but keep in mind that they will tend to run very hot if operated at a point near their maximum ratings. It is preferable to select diodes with a 25 or 50 percent margin. For example, for a 20-ampere power supply select a 25- to 30-ampere diode. Also keep in mind that the minimum peak inverse voltage (PIV) rating must be not less than 2.82 times the applied RMS voltage. This is not too much of a problem in +5-volt circuits operated from 6.3-volt transformers, but is very definitely a factor at higher voltages. You cannot, for example, use a 25-volt PIV rectifier in a 12-volt DC supply!

TABLE 1—TYPICAL FILAMENT TRANSFORMERS

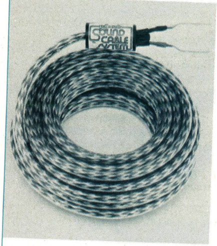
Triad No.	Secondary voltage	Amperes
F-22U	6.3VAC	20
F-24U	6.3/7.5 VAC	8
F-28U	6.3/7.5VAC	25
F-56X*	25.2 VAC	2.8

*Ideally suited to making the ±12 volt regulated supplies needed for most microcomputers. Use a fullwave bridge *and* the transformer center tap to form two halfwave bridges. This supply will deliver up to 1 ampere at each voltage.

Capacitor C1 in Figs. 1 and 2 should have a capacitance of *not less* than 2000 μF-per-ampere of load current. In a 20-ampere supply, then, the filter capacitor should be at least 40,000 μF. It should have a DC working voltage rating of at least 15 volts (WVDC). I used an 80,000 μF/15 WVDC capacitor in testing these circuits with a 15-ampere load. The 2000 μF-per-ampere spec is a *minimum*, not an *optimum*, rating.

The 5-volt, 5-amp supply

The Lambda Electronics (515 Broad Hollow Rd., Melville, L.I., N.Y., 11746) model LAS-1905 is one of the most powerful



SPEAKER
how various types

Recently audio engineers have found that ordinary that a loudspeaker sounds. Newly developed

THERE IS A GROWING BODY OF OPINION IN some audio circles that speaker cables have been neglected when considering the performance of a high-fidelity system. However, when one prominent speaker engineer was asked what part he felt cables contributed to speaker performance, his answer was: "Ever since I discovered that no one—not you, not I—can hear the difference between 10-kHz sinewaves and squarewaves, I've been cynical of the claims made by the ultra-wide band and no-phase-shift advocates." He was referring to the fact that research has shown that even the best-quality conventional speaker cable cannot pass a squarewave, and causes phase rotation at high frequencies.

Today's thinking has it that the inductance and capacitance of lamp cord (zip cord) should not present a problem in today's audio systems. However, it is generally conceded that for very long runs of speaker wire that is connected to low-impedance speakers, it might be necessary to artificially lower the cables' typical impedance. Therefore, if we assume there is no significant magnetic coupling to other cables capable of absorbing power in low-impedance circuits, there is no reason to believe that speaker cable should significantly affect frequency response.

If you visit some hi-fi stores today, you'll find an increasing number of so-called "super cables," such as Disc Washers' *Smog Lifters*, Polk's *Sound Cables*, Audio Source's *High Definition Cables*, M & K's *Mogami* cables, or the Fulton line of cables. These represent several different types. For instance, 140-strand braided cable (*Smog Lifters*); 10 pairs of braided insulated wires (Audio Source's *High Definition*); a stacked coaxial cable (M & K's *Mogami*); the Fulton cable, which is a very large parallel multishroud type, or the Polk cable, which is also braided with a very fine intertwine. The price of these cables runs from 50 cents-per-foot to \$1.50-per-foot and more, making them considerably more expensive than conventional zip cord that costs 15 cents or less per foot. Zip cord is usually recommended by most audio stores and industry authorities.

It is stated in a typical amplifier instruction manual that No. 18 lamp cord is sufficient for normal lengths (to about 30 feet) between speaker and amplifier. However, No. 16 wire is generally recommended depending on distance. A leading speaker manufacturer has prepared a recommended connection-wire chart that is shown in Table 1.

The wire lengths listed in Table 1 were calculated on a maximum audible coloration of ± 0.5 dB. Following the guide lines provided, the most discerning listener will be unable to detect any coloration introduced by the speaker wire. Most listeners will not notice any effect even if wire lengths are increased as much as 50%.

Audio critics like Leonard Feldman, **Radio-Electronics'** Contributing High-Fidelity editor, have stated that the damping factors of a good amplifier can be practically eliminated by a poor hook-up to the speakers, and you should play it safe by using heavy wire and making good connections. Even the finest cables can be rendered ineffective with poor connections.

TABLE 1—Recommended Connection Wire

Maximum wire length (ft)	Wire gauge
30	18 gauge, zip cord (or two-conductor wire)
45	16 gauge, two-conductor wire
70	14 gauge, two-conductor wire

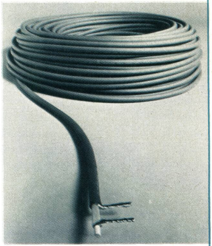
Speaker designer Roy Cizek has emphasized in a series of articles and speeches to audio groups that "even the 'heavy' gauges No. 14 and No. 16 lamp cord are often insufficient." Mr. Cizek discovered that even small amounts of resistance can affect frequency response by destroying the effective damping of the amplifier-speaker system. He also pointed out the effects of a speaker-line fuse, and recommended using No. 12 or No. 10 wire.

Both Mr. Feldman and Mr. Cizek have pointed out that using heavier speaker wire should not be just the concern of the audiophile trying to extract the last bit of performance out of a hi-fi system. Most audio systems sold have 25 watts of amplifier power or less, and combined with a low-impedance speaker, certain wire lengths may throw away up to 30% or 40% of the amplifier power. As Mr. Cizek states, "contrary to common practice, it can be especially important to use heavier wire with smaller amplifiers or receivers, since they have low power output and low damping factors to begin with."

What the advocates of better cables point out is that many speakers are designed to provide good efficiency and transient response when effective damping is high. The low internal impedance of today's modern transistorized amplifiers reduces the amplifier's damping capability. With a low damping factor, the speaker continues to vibrate after the signal is cut off, which results in muddiness and overhang. Good speaker damp-

CABLES affect sound

speaker cables can adversely affect the way cables of unique construction solve the problem.



HARRY MAYNARD

ing plays the same role as a shock absorber on a car, preventing the suspension system from overoscillating on a bumpy road. The damping factor of a good amplifier can be critical to reproducing sharp, clean transients and to the integrity of the bass.

Those who champion the new super cables claim that the damping factor can be rendered ineffective because the speaker impedance can be increased by up to two or three measurable ohms by using zip cord. The goal is to keep the impedance of the speaker cable low.

The damping factor is defined as the ratio between speaker impedance and amplifier output (or internal) impedance. Mr. Cizek's recommendation of No. 12 or No. 10 wire is based on the assumption that "if you decrease the effective damping factor by using a small wire and fuse in the line you tend to produce peaks in the frequency response corresponding to those in the impedance curve as well as poor response and increased ringing." (See Fig. 1.)

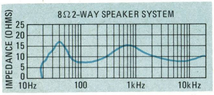


FIG. 1—SMALL WIRE DECREASES the effective damping factor and produces peaks in the frequency response.

Now the plot thickens. On several trips to Japan I discovered that leading Japanese companies presently offer for sale super cables of varying configurations; for example, J.V.C.'s *Super Cord* (sold only in Japan, not in the U. S.). You will also find Pioneer cable and several other brands. The merits of various cables is a topic of much discussion among Japanese audiophiles, who are a match in their enthusiasm for high-quality audio with any audiophiles in the world. Much of the advanced research on the effect of speaker cable on hi-fi systems has been done in Japan.

Using a pair of J.V.C. *Super Cords*, my not-too-golden ears detected a significant improvement in sound quality coming through my speakers as compared with the No. 16 wire I had been using. I have since experienced the same improvement in sound quality with a wide variety of super cables compared with conventional cables.

Research conducted by J.V.C. showed that conventional cable could not pass a 100-kHz squarewave and that there was phase rotation. In addition, the magnetic fields of wires running parallel to each other set up what is known as self-inductance. Parallel wires create phantom channels to each other and round off high frequencies. In tests, several researchers have discovered this results in a loss of audio articulation.

In discussing the merits of super cable and various experiments conducted by J.V.C. and other electronics manufacturers, several leading Japanese executives admitted that there was much that the audio industry has yet to learn about the complex interfaces of different speaker cables and amplifier-speaker combinations. To condemn certain amplifiers because they do not perform properly with certain speakers is similar to condemning certain high-performance cars when given improper fuel—it is an unfair judgment.

Perhaps the most extensive research was performed by Kenwood in Japan in developing their *model L-07M* amplifier and *model L-07C* preamplifier. Discovering the effects of "the neglected cable," as described by Kenwood engineers, occurred quite by chance. Kenwood feels that the super cables "have yielded improvements in sound quality on account of their superior transmission qualities," but this is only part of the picture. A speaker cable has to be considered an extension of the amplifier.

The problem is carefully defined and fully explained in the 47-page owners' manual (No. 7454859-0084-00) for the *model L-07M* amplifier and *model L-07C* preamplifier system. For those who wish to delve deeply into the complex interface problem of speaker/wire/amplifier, I strongly recommend getting this manual. We can only summarize its main points here.

Kenwood engineers, using very elaborate testing techniques, found that the speaker-cable impedance plays a significant role in high-frequency response and that the DC resistance contributes significantly to distortion (see Fig. 2). Furthermore, they claim that there is "surprisingly large distortion at the speaker inputs that is caused by speaker cables of even high quality and emphasizes the importance of solving this problem." (See Fig. 3.)

The importance of the neglected cable was discovered by measuring various energy losses for different lengths and kinds of cables. The greatest losses, even when using the best cables, could be held to from 0.5 dB to 0.6 dB below 10 kHz but there were still problems above 10 kHz. As described by Kenwood engineers, "when we made actual listening tests, we sensed there was something missing. It was like a bucket with a hole near the top and performance never went above the level of that hole.

"So our engineers devised a new test using a 30-kHz tone burst and measuring cable performance at the speaker terminals. They found that although the pulse

signal was perfect, there was a deformation of the waveform. The difference in wave height and overshoot is actually caused by the counter-electromotive force from the speaker, the result of greater resistance and weaker damping of the long cable. Fundamentally, even very low distortion, which cannot be measured, can be detected by our sense of hearing."

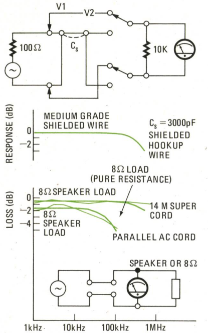


FIG. 2—SPEAKER-CABLE IMPEDANCE has a significant effect on high-frequency response.

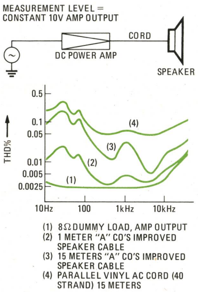


FIG. 3—SPEAKER CABLE CAN CAUSE surprisingly large distortion at the speaker inputs.

The most disturbing finding was that the amplifier should ideally be located much closer to the speakers—this is hardly reassuring for the millions who can't or find it inconvenient to do so. The farther the speaker is from the amplifier the slower the slew rate.

Obviously, to do away with the speaker

TABLE 2—Comparison of Audio Cable and Speaker Cord

	Audio cable	Speaker cord
Role	Voltage transmission	Power transmission
Transmitting impedance	10 ohms ~ 1000 ohms	Almost zero
Load conditions	20 ohms ~ 100,000 ohms. Changes somewhat with frequency and is constant without regard to signal level; slight input capacitance only; no reactance.	Indication 4~14 ohms. Changes considerably with frequency; changes with signal level; reactance component is large and complex; counterelectromotive force produced by speaker.
Effect on performance	Small	Large
Effect on tonal quality	Small	Large
Change with length	Small	Large
Extraneous induction	Easy	Difficult
Effect of cord characteristics	Since the load conditions other than component C are large, effect is small.	Components L, C and R have a large effect.

Note: In the past the quality of the system was not improved while pursuing the characteristics on the amplifier side because the dynamic characteristics with the speaker connected such as these were not considered. As shown in Fig. 7, the deterioration in distortion when the speaker is connected exceeded our imagination.

cable is impractical. Kenwood found however that their specially developed cable (not sold in the U. S.) could be used up to one meter (3.25 feet) from the speaker system, with virtually no effect on tonal quality. On the other hand, the audio cable between power amplifier and control amplifier can be long since it is merely a signal transmission line (see Table 2). I know some people who have suffered from RF problems, which they claimed was only eliminated by using specially constructed (expensive) audio cables like Verion, who might suggest that audio cables are important too. But that's another subject.

The Kenwood solution is obviously directed at the perfectionist audiophile (assuming you agree with their analysis of the problem). There are alternative solutions if you agree that the problem of transmission losses does exist and *can be heard*. If you don't like the price of the super cables, for less cost you can use the heaviest zip cord you can find, if your amplifier is not bothered by capacitance problems. Don't be afraid of reducing the size of the wire at the speaker terminals (by no more than half) so it will fit into spring-loaded speaker or amplifier terminals. But be careful, since the total resistance of the length of the wire must be considered.

If you believe that there is a problem of self-inductance, you'll usually find that the super cables are sold on a money-back basis. So if you don't hear a difference you can return them. Most of the special cables are sold by specific lengths and several have special tip ends that allow you to make excellent uniform connections.

For example, Disc Washers' *Smog Lifters*, shown in Fig. 4, have special plastic Y-finished tip ends that resist potential shorting, these cables sell for $1.40-per-foot.

The M & K *Mogami* cable (sold for $1.50-per-foot) must be debraided, and should not be tinned if splicing is neces-

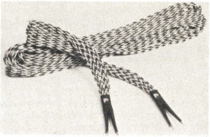


FIG. 4—DISC WASHERS' *Smog Lifter* cables have special plastic tips.

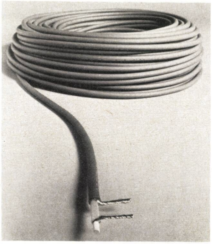


FIG. 5—M & K *MOGAMI* cable must be debraided; no tinning before splicing.

sary. (See Fig. 5.) A firm connection between the wire ends to be joined should be made before soldering. You are also warned to avoid speaker switches,

continued on page 93

How To Design Digital Circuits

Part 1—With digital circuitry becoming an increasingly important factor in our everyday lives, it's time that we learn how to design logic circuits. Get in on the start of this series as the author discusses digital logic design—beginning with Boolean algebra and Karnaugh maps.

JERRY WOOLSEY

TODAY'S ELECTRONICS HOBBYIST HAS available to him a previously undreamed-of assortment of hardware for his projects. Whereas 15 or 20 years ago electronics magazines ran construction articles on simple two- or three-tube circuits, using point-to-point wiring, the projects of today consist of computer CPU boards and computer terminals on complicated double-sided PC boards. Digital circuits are now appearing in almost everything electronic, including "linear" applications such as tuners, TV sets and synthesizers.

To enjoy fully the electronic technology of today, a hobbyist needs to know not only how to bias transistors and match impedances, but also how to analyze and design digital circuits. Although most experimenters can do this using brute-force methods, *there are some fairly simple methods for reducing the number of gates in*, and hence the complexity of, a digital circuit.

Digital electronics is the realization of Boolean algebra, and some knowledge of it is required to design a digital circuit. Since the subject of Boolean algebra has been covered in magazine articles as well as in many textbooks, it is assumed the reader has a fair knowledge of it, and is able to write his desired function in both equation and truth-table form. In this article, we will see how to apply the fundamentals of Boolean algebra to construct both parallel and series circuits from a truth table, and then *reduce the gates to the minimum needed.* Throughout this article, the AND function will be implied between two variables if no operator is given between them, i.e., $x \cdot y$ will be written simply as xy.

Combinational switching circuits

A *combinational switching circuit* is a digital circuit whose output at any time is dependent only on its input at that time, regardless of any previous input or output. Thus, no "memory" circuits are included. (A flip-flop is considered a memory circuit.) The first part of this article is concerned only with these circuits.

A Boolean equation, no matter what form, can always be reduced or expanded to give an equation in either a sum-of-products (S-P) or product-of-sums (P-S) form. In the S-P form, the equation is an OR (sum) of several AND (product) groups. In the P-S form, the equation is an AND of several OR groups. As an example, take the following equation:

$$a = x(y + z) + y \qquad 1)$$

This can be expanded by multiplying through the x to get

$$a = xy + xz + y \text{ (S-P)} \qquad 2)$$

which is in S-P form, or may also be written in P-S form as

$$a = (x + y + z)(x + y + \bar{z})(\bar{x} + y + z) \text{ (P-S)} \qquad 3)$$

A primitive implementation of equation 1 is shown in Fig. 1, using the S-P form of the equation. So we pick up the IC data book and notice one peculiar thing: almost all the gates available are NAND, with several AND, but few OR and NOR types. Why should this be so when most functions are written as strictly AND and OR? To understand why, we can apply DeMorgan's theorem to equation 2. This theorem states that if we invert the individual members of one side of an equation, then change the signs between members from AND to OR and vice-versa, then invert the entire side of the equation, the equation is still true. To illustrate, let's apply this theorem to equation 2. First, we invert the individual members to obtain

$$a = \overline{xy} + \overline{xz} + \bar{y}$$

Now we change the signs between members and get

$$a = \overline{xy} \cdot \overline{xz} \cdot \bar{y}$$

Finally inverting the entire string, we get

$$a = \overline{\overline{xy} \cdot \overline{xz} \cdot \bar{y}}$$

This says that to obtain the result a, we NAND x and y, NAND x and z, INVERT y, and NAND the three results. Figure 2 shows the logic circuit. Thus, the NAND gates can perform the AND and OR functions. When a group of NAND gates feed another NAND gate, the first gates perform an AND function, and the gate they feed performs the OR function on each AND'ed group. We thus only need to keep a supply of NAND gates to realize any equation in S-P form. In this case, an extra inverter is needed, but inverted variables are often already available from another output, and even if not, this could be performed by a NAND, keeping the three input gates on one package.

It should be noted that the P-S form can be implemented in circuit form by using NOR gates, the first input gates

perform the OR function, and the second set of gates perform the AND function. However, P-S forms can always be expanded to S-P forms, so the remainder of the article will deal only with S-P forms.

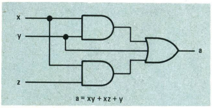


FIG. 1—LOGIC CIRCUIT that performs the Boolean algebra expression shown.

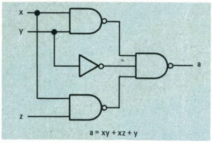


FIG. 2—NAND GATES can be used to perform the same function as shown in Fig. 1.

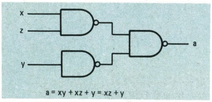


FIG. 3—SIMPLIFIED LOGIC CIRCUIT is equivalent to circuit shown in Fig. 2.

Using the theorems of Boolean algebra, it can be seen that equation 2 can be reduced to:

$$a = xz + y$$

This means that the circuit shown in Fig. 3 is equivalent to the one shown in Fig. 2. Obviously, this is much simpler, and can be done on only one IC.

Reduction of mathematical expressions by Boolean algebra theorems is tedious and often hit-and-miss. To alleviate the problem, we turn to a tool that eliminates much of the work.

The Karnaugh map

The Karnaugh map is simply a rearranged truth table that can readily give valuable information for circuit design and reduction. There are 2^n boxes in the map, where n is the number of inputs to the circuit. Each row and column is numbered in binary, and the value in each box is the output of the circuit when the coordinates of the box are the input. The numbering of the columns starts at the left at zero, and is arranged such that the number of the next column to the right differs in only one bit position. Thus, 00 is followed by 01, which is followed by 11, which is followed by 10. The rows are numbered similarly. Figure 4 illustrates the numbering and the corresponding decimal coordinates of the boxes for functions with two, three and four inputs. Beyond four inputs, the Karnaugh map becomes too cumbersome, so other methods have been designed for these situations.

As an example, suppose a three-input circuit with inputs x, y and z were to produce a logic-1 output when $x = 0$ and $y = z = 1$. Then we would enter a 1 into the box numbered 3 in Fig. 4-b ($xyz = 011 = 3_{10}$). If a zero were to be produced when $x = y = 1$ and $z = 0$, the box numbered 6 would contain a zero. In certain cases, such as BCD circuits, some input combinations are meaningless (1010 is not a BCD number). In these instances, we enter a "d" in the appropriate box to indicate a "don't-care" condition. This tells us the output may be either 0 or 1 with the given input, since that input would never occur. This may be used to further aid in circuit reduction.

Figure 5-a shows the truth table for equation 1, and Fig. 5-b shows the Karnaugh map derived from it.

Now we come to the interesting property of the map. By definition of the structure of the map, any two adjacent boxes (horizontally or vertically, but not diagonally) differ in coordinates, i.e., in input conditions, by only one bit. For example, the boxes where ($x = 0, y = z = 1$) and ($x = z = 0, y = 1$) are adjacent, and differ in coordinates in only the z-input. This property also holds when "wrapped-around," i.e., the top right-hand box ($x = z = 0, y = 1$) is adjacent to the top left-hand box ($x = y = z = 0$), since they differ only in the y-bit of the coordinate. The same holds true for vertical wrap-around. Two of these adjacent boxes are said to form a 1-cube, since there are 2^1 boxes in the cube.

Now refer to Fig. 5-b. If we take two adjacent boxes that contain a 1, for example ($x = z = 1, y = 0$) and ($x = y = z = 1$), we find that the output of the circuit must be a 1 whenever $x = z = 1$, independent of the value of y. That is, whenever xz is true, the equation is true. Similarly, box ($x = 0, y = z = 1$) and box ($x = z = 0, y = 1$) are adjacent and contain ones, so we see that the output is true whenever $x = 0$ and $y = 1$, independent of z. Thus, $\bar{x}y$ being true will cause the equation to be true, or a 1 to be output. Taking all combinations of two adjacent boxes, both of which contain a 1, the following equation is derived

$$a = xz + \bar{x}y + xy + yz + y\bar{z}$$

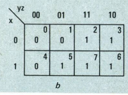
which is equivalent to equation 1, but is obviously not reduced. The reason for this is that several conditions for an output have been duplicated by more than one term of the equation. For example, if $x = y = z = 1$ is entered, the three terms xy, xz and yz will all be true, causing the output to be true, but it is only necessary to have one term true to cause the output to be true. Thus, we have redundant members in the equation. If we take only three adjacent sets of boxes to cover all the 1-outputs, we can obtain the equation

$$a = xz + \bar{x}y + xy$$

Now all the boxes containing a 1 have been covered by at least one of the terms of the equation, which means that the equation is a true representation of the truth table. But the equation is still not completely simplified. If we look at the 1-cube (two adjacent boxes) consisting of ($x = 0, y = z = 1$) and ($x = z = 0, y = 1$), and the 1-cube consisting of ($x = y = z = 1$) and ($x = y = 1, z = 0$), we see that the output of the function is always 1 whenever $y = 1$, regardless of the value of x or z. Thus, we have formed a 2-cube (2^2 boxes), and have found that $y = 1$ satisfies the conditions for generating a logic-1 output for each of the four boxes. Note that, in looking at the coordinates of each of these boxes, y is the only coordinate that does not change, and is always 1. We need now to cover only one more box where a logic-1 output is to be generated, box ($x = z = 1, y = 0$). To do this, we

x y z	COORDINATE VALUE	a = xy + xz + y
0 0 0	0	0
0 0 1	1	0
0 1 0	2	1
0 1 1	3	1
1 0 0	4	0
1 0 1	5	1
1 1 0	6	1
1 1 1	7	1

a



b

FIG. 5—TRUTH TABLE for equation a = xy + xz + y is shown in *a* and resulting Karnaugh map derived from the truth table is shown in *b*.

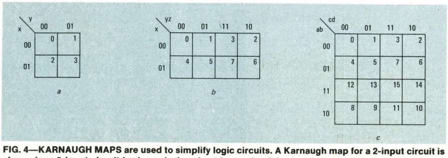


FIG. 4—KARNAUGH MAPS are used to simplify logic circuits. A Karnaugh map for a 2-input circuit is shown in *a*, 3-input circuit is shown in *b* and a 4-input circuit is shown in *c*.

could simply say we need $x\bar{y}z$ to be true for the output to be a logic 1, but we have another adjacent 1-labeled box ($x = y = z = 1$) and if we use this to form a 1-cube, that term of the equation reduces to xz, since a 1-output is independent of y if x and z are 1. Thus, we obtain

$$a = y + xz$$

as our final equation, and implement it as shown in Fig. 3.

When "d" (don't-care) outputs are specified, these are included as 1-outputs if it enables us to make larger cubes with other 1-outputs, hence simplifying the equation, or as 0-outputs if they are not used in making larger cubes.

Even larger cubes may be found in four-input functions. A 1-cube is two adjacent boxes containing either a 1 or "d"; a 2-cube is two adjacent 1-cubes (i.e., a 2×2 box or 4×1 horizontal or vertical row); and a 3-cube is two adjacent 2-cubes (i.e., a 4×2 horizontal or vertical box). If a map consists only of 1- and d-labeled boxes, the function is always true, or a constant 1.

The step-by-step procedure for circuit reduction, then, is as follows:

1) Draw the truth table, and fill in the boxes of the Karnaugh map with a 1, 0 or d, using the inputs as coordinates and the outputs as box entries. For example, see Figs. 6-a and 6-b.
2) Examine the map for any 3-cubes, i.e., a 4×2 box containing no zeroes. Don't forget to check for possible wrap-around. In Fig. 6, a 3-cube is formed by decimal coordinate boxes 0, 1, 2, 3, 4, 5, 6 and 7 (see Fig. 4-c). The coordinates abcd of these boxes are examined, and it is found that b, c and d take on all values (0 and 1) while a is always 0. Thus, when $a = 0$, the output is always 1 independent of b, c and d, so one term of the final equation is simply $\bar{a}$. Place a check in each of the boxes of this 3-cube to indicate that they have been covered. When the coordinates of any of these boxes are input, the output will be 1 simply because $\bar{a}$ is 1. The map now appears as in Fig. 7-a.

ab \ cd	00	01	11	10
00	1 √	1 √	1 √	d √
01	d √	1 √	d √	1 √
11	0	d	1	0
10	1	0	0	1

a

ab \ cd	00	01	11	10
00	1 √	1 √	1 √	d √
01	d √	1 √	d √	1 √
11	0	d √	1 √	0
10	1 √	0	0	1 √

b

FIG. 7—KARNAUGH MAPS are reduced by first looking for a 3-cube (a 4 × 2 box containing no zeroes). When a 3-cube is found, check the individual boxes as shown in *a*. Next, look for 2-cubes and check these boxes as shown in *b*.

3) Examine the map for any 2-cubes, that is, any 2×2 or 4×1 box containing no zeroes, and at least one 1-labeled box not yet checked. In our example, decimal boxes 5, 7, 13 and 15 form such a cube. Examining the binary coordinates of these boxes, we find that b and d are always 1, while a and c may take on any value. Thus, our second term of the equation is bd, giving $f = \bar{a} + bd$ so far. Check off the boxes covered by the second term. Check for more 2-cubes. In the example, we have another 2-cube that is not so obvious, due to wrap-around. This is the cube containing decimal boxes 0, 2, 8 and 10. From the binary coordinates, we find b and d are always 0, while a and c can take on any value. Thus our next term for an output of 1 is $\bar{b}\,\bar{d} = 1$, and our function is now $f = \bar{a} + bd + \bar{b}\,\bar{d}$. Check off the boxes covered. The map now looks like Fig. 7-b.
4) Examine the map for any 1-cubes, i.e., two adjacent boxes each containing a 1 or a d that also contains one 1-labeled box not checked. Write down the nonvarying coordinates as a term of the function, and check for more 1-cubes. No 1-cubes remain in the example.
5) If any 1-labeled boxes remain unchecked, write down their coordinates as a term of the function. For example, if the box with coordinates ($a = 0$, $b = c = d = 1$) contained a 1 but was not yet checked off, we would write the coordinates as $\bar{a}bcd$ and insert it as a term in the equation. At the completion of this step, all boxes with a 1 in them should be checked off.
6) By inspection, make sure no cube is completely covered by other cubes. Each cube, no matter what size, must contain at least one 1-labeled box not contained in any other cube. If it does not, discard its corresponding term from the equation.
7) OR all the terms derived above to get the final reduced function. In our example we get:

$$f = \bar{a} + bd + \bar{b}\,\bar{d}$$

8) Feed each term into a NAND gate, and feed the outputs of the NAND gates to another NAND gate. The circuit is complete. See Fig. 8-a.

In searching for cubes to cover an unchecked 1-labeled box, the largest possible cube should be chosen, even if it covers other boxes already checked, so that the number of inputs to each gate is minimized.

Note that Fig. 8-a has $\bar{a}$ as an input that simply gets inverted before going to the output gate. Instead of this, it would be simpler to feed a directly to the output gate, as in Fig. 8-b. Also note that the

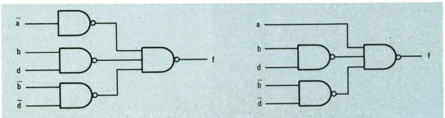
a	b	c	d	OUTPUT	DECIMAL
0	0	0	0	1	0
0	0	0	1	1	1
0	0	1	0	d	2
0	0	1	1	1	3
0	1	0	0	d	4
0	1	0	1	1	5
0	1	1	0	1	6
0	1	1	1	d	7
1	0	0	0	1	8
1	0	0	1	0	9
1	0	1	0	1	10
1	0	1	1	0	11
1	1	0	0	0	12
1	1	0	1	d	13
1	1	1	0	0	14
1	1	1	1	1	15

a

ab \ cd	00	01	11	10
00	1	1	1	d
01	d	1	d	1
11	0	d	1	0
10	1	0	0	1

b

FIG. 6—TO SIMPLIFY a logic circuit, first draw a truth table that represents the circuit function as shown in *a*. Next, a Karnaugh map is derived from the truth table as shown in *b*.



a b

FIG. 8—LOGIC CIRCUIT is derived from reduced Karnaugh map and is shown in *a*. Inverter can be eliminated as shown in *b*.

output of the gate fed by bd cannot be used as input $\bar{b}\,\bar{d}$ to the gate below it since $\bar{b}\,\bar{d} \neq \overline{bd}$.

As was noted earlier, the Karnaugh map method is too difficult beyond four inputs. The designer has to start considering mirror-images, and mistakes are easily made. It also does not reduce the circuit fully if multiple outputs are desired, as in a BCD to seven-segment decoder. Fortunately, there is another fairly simple method to use in these cases.

Quine-McCluskey method

The Quine-McCluskey method works on the same principle as the Karnaugh map, but is performed in tabular form. As an example of this method, we will construct a circuit to produce a 1-output, called f, whenever a 2-bit number A, whose bits are designated as a_1 and a_2, is larger than a 2-bit number B, whose bits are b_1 and b_2. The truth table for this function is given in Fig. 9.

a_1	a_2	b_1	b_2	f
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0

FIG. 9—QUINE-McCLUSKEY METHOD is used when a circuit with four or more inputs must be designed. First a truth table describing the circuit function is generated as shown.

NO. OF 1-BITS	INPUT (DECIMAL EQUIVALENT OF $a_1\,a_2\,b_1\,b_2$)
1	4 8
2	9 12
3	13 14

FIG. 10—ADJACENT BOXES and cubes are determined in a table generated from the truth table shown in Fig. 9.

The Karnaugh map obviated adjacent boxes and cubes. In the Q-M method, we write down a table to help show adjacency (see Fig. 10). The decimal value of each set of inputs that will generate either a 1- or don't-care output is listed in ascending order in groups according to the number of 1-bits in the input. For example, $A = a_1a_2 = 10$ and $B = b_1b_2 = 01$ produces a 1-output, and the number of 1-bits in A and B is two, so a 9 ($a_1a_2b_1b_2 = 1001$) is placed in the 2-bits group. Within each group, the decimal inputs are listed in ascending order. It can now be seen that two inputs producing a 1-output are adjacent, in the same sense as in the Karnaugh map, if three conditions are met:

1) The number of 1-bits of each input differs by exactly one.
2) The decimal input with the smaller number of 1-bits must be smaller than the input with the larger number of 1-bits.
3) The difference of the two decimal inputs must be a power of two.

According to condition 1, inputs listed in the 3-bit group can only be adjacent to inputs in the 2-bit or 4-bit groups; inputs in the 1-bit group can only be adjacent to inputs in the 0-bit or 2-bit groups, etc. This is consistent with the definition of adjacency being a difference in only one bit of the input.

According to condition 2, the decimal input 4 may be adjacent to decimal input 12, since 4, having fewer 1-bits than 12, is smaller than 12. If, for example, the decimal input 3 produced a 1-output, it would be placed in the 2-bits group, but could not be adjacent to 4, since it has more 1-bits but is less than 4. This would cause more than one bit in the input to be different.

Condition 3 is obvious, since only one input bit may differ for adjacency. If the difference of the two numbers is not a power of two, more than one bit differs.

NO. OF 1-BITS	INPUT	1-CUBES
1	4 ✓ 8 ✓	4,12 (8) 8,9 (1) 8,12 (4)
2	9 ✓ 12 ✓	
3	13 ✓ 14 ✓	9,13 (4) 12,13 (1) 12,14 (2)

FIG. 11—SIMPLIFICATION starts by listing the 1-cubes.

We now use these rules to make a third column, consisting of a list of adjacent boxes, or 1-cubes. We take the first input number in the table, 4, and check it for adjacency with the entries in the next bit group. Box 4 is not adjacent to 9, since the difference, 5, is not a power of two. Box 4 is, however, adjacent to 12, since the difference is 8, and 4 is less than 12. Thus, we enter into the third column the numbers 4 and 12 together, with their difference in parentheses (see Fig. 11). Since the inputs 4 and 12 have been covered by a higher cube, we place a check next to them in the column labeled input.

The input 4 cannot be adjacent to any other bit group, so we look at input 8. Box 8 is adjacent to 9, since the difference is a power of two, so we enter the numbers and difference as a 1-cube and place a check next to the 8 and 9 inputs to indicate they have been covered by a higher cube. Box 8 is also adjacent to box 12, so we repeat the process for them. Since we are through checking the 1-bit group, we place a line under 8,12(4) in the 1-cube column and start checking the 2-bit group. Box 9 is adjacent to box 13 but not to box 14. Box 12 is also adjacent to box 13, as well as 14, and we are finished creating 1-cubes. The 1-cube column now contains a list of all the possible 1-cubes that could be extracted from the Karnaugh map. Since all the inputs in the input column have been checked off, they are all contained in higher cubes.

We now have two groups of 1-cubes, and use these to form 2-cubes. The same conditions hold for forming adjacent cubes, except now the numbers in parentheses must also match. Looking at the first 1-cube entry, 4,12(8), we see that it is not adjacent to any 1-cube in the second group, since none have an 8 in parentheses. Going to 8,9(1), we find an entry, 12,13(1) in the second group that has the same number in parentheses. Since the difference of 8 and 12 (or 9 and 13) is also a power of two, and 8 is less than 9 and in a lower group, we enter this in the next column as a 2-cube, and indicate both the first and second differences in parentheses. The two entries that formed this cube are checked, since they are covered by the higher cube (see Fig. 12).

Another entry, 8,12(4), is adjacent to the entry 9,13(4), so it is entered as a 2-cube and the separate 1-cubes are checked. However, this is identical to the previous 2-cube and is thus stricken. No further adjacency is found, and there are no more groups to check for adjacency, so the checking of the 1-cube column is complete.

We now go to the next column and continue until no adjacencies are found. The same rules are followed in each column, checking each entry against each

continued on page 92

NO. OF 1-BITS	INPUT	1-CUBES	2-CUBES
1	4 ✓ 8 ✓	4,12 (8) 8,9 (1)✓ 8,12 (4)✓	8,9,12,13 (1,4)
2	9 ✓ 12 ✓		
3	13 ✓ 14 ✓	9,13 (4)✓ 12,13 (1)✓ 12,14 (2)	

FIG. 12—ALL 2-CUBES are listed. Second 2-cube is crossed off since it is covered by first entry.

BUILD THIS

REMOTE TELEPHONE EAR–

Listen via Long Distance

This device—the fourth in a series of phone gadgets—lets you monitor sounds in your home or office when you call your telephone from a remote location.

JULES H. GILDER

IN THE APRIL AND MAY 1977 AND MAY 1978 issues, we showed how to construct add-on telephone accessories that let you turn on and turn off various household appliances by remote control, build a hands-off telephone amplifier and assemble an autodialer and cassette interface that dialed authorities or neighbors in case of a fire or intruders in your home.

If you were interested in these items, you'll flip over the Remote Ear that lets you dial your home phone and then listen for the sound of running water or a radio that was inadvertently left on. Or maybe you just want to check your house and see that everything is quiet and no one has broken into it.

The Remote Ear is an adaptation of the Teleswitch circuit (April 1977). It automatically connects a microphone and amplifier to the telephone so that you can monitor a remote location. As you will quickly see from the schematic, the Remote Ear uses the same type of signal detectors as the Teleswitch. However, instead of having controlled outlets to turn devices on and off, the Remote Ear has a small three-transistor amplifier connected to it.

This amplifier is identical to the one described in the Speakerphone circuit (May 1977). Its signal is very clear and audible. The output of the amplifier, which is located in the area that you want to monitor, is fed to a small speaker that is acoustically coupled to the telephone mouthpiece.

Since it is unlikely that remote listening will be done for long periods of time, the Remote Ear has a built-in timer that allows you to listen for about three minutes. Longer or shorter listening times can be set by adjusting the timing resistor in the emitter circuit of unijunction transistor Q2.

About the circuit

Sound switch 1 and the unijunction timer that is associated with it (Q1) are the same as were used in the Teleswitch. Sound switch 2, however, is slightly modified. Instead of having one relay connected to the 2N3904 collector, there are two relays, RY2 and RY4.

The operation of the Remote Ear involves several steps. When the telephone rings the first time, sound switch 1 triggers and causes RY1 to close. This applies power to sound switch 2 and to the two timing circuits consisting of unijunction transistors Q1 and Q2.

If the phone rings more than once, within 20 seconds sound switch 2 triggers and RY 2 closes. Contact RY2-1 disconnects the power from the first unijunction transistor timing circuit and from sound switch 1. This prevents the Remote Ear from being activated and makes it necessary to wait three minutes before the next attempt.

If, however, the phone rings only once, there is enough time for a charge to build up on C1 and for Q1 to trigger, activating RY3. When RY3 is activated it switches the RY2 coil out of the control circuit of sound switch 2 and replaces it with the RY4 coil.

The first time the telephone rings only once it arms the circuit. The next time the telephone rings it turns on the listening circuitry. This is done by sound switch 2 activating RY4, which, in turn, controls the amplifier and the answering solenoid.

Relay RY4 latches closed and is held in that position until a reset pulse from unijunction timer Q2 turns off the 2N3904 controlling RY2 and RY4 and unlatches SCR2.

The telephone is actually answered by a solenoid that pulls up when RY4 closes. This releases the cradle switch and answers the phone. The handset of the telephone is placed on the table alongside the telephone. The loudspeaker connected to the output of the amplifier is held next to the mouthpiece (rubber bands can be used). Thus, the sound picked up by the crystal microphone is amplified and acoustically coupled to the telephone.

After three minutes, or whatever time period you selected has elapsed, a reset pulse is generated and the bases of the control 2N3904's are brought to ground potential, turning these transistors off and unlatching the SCR's. The unit is now ready for its next monitoring period.

Construction

This project is constructed from four modular circuits. The first two circuits are sound switches identical to those built in the Teleswitch (April 1977). After the sound switches are built, they should be mounted in a metal chassis that is large enough to be placed under the telephone. A 5 × 9 × 2-inch aluminum chassis was used for the prototype. A ⅛-inch hole should be drilled where each of the crystal microphones is mounted so that sound will reach them more easily.

After the sound switch modules are mounted, assemble the control module using the circuit shown in the schematic. The circuit can be fabricated by wiring

the components on perforated board or you can design a printed circuit.

After the control module is completed, mount the board, using spacers, at any convenient spot under the chassis. The only component left to be mounted is the amplifier. The amplifier used here is identical to the one used for the Speakerphone. Mount this module also on the chassis, using spacers.

Once all four modules are mounted, do the relays. Now connect all the wires solenoid until the fully extended plunger holds the cradle switch down. Attach the solenoid to the wooden support with two screws.

Now attach two conductors of conventional lamp cord to the two terminals on the solenoid. Then, insulate these terminals with electrical tape. Bring the lamp cord down the support, attaching it to the wood in several places with staples. Be careful that staples do not pierce the insulation of the wire, causing a short circuit. radio. Place the speaker next to the telephone mouthpiece.

Ask a friend to call and let the telephone ring several times. On the first ring, RY1 should close. On the second ring, RY2 should close, opening RY1. After three minutes, a reset pulse from Q2 should reset the lower SCR opening, RY2.

After another three minutes have passed and RY2 has reset, have your friend call again, tell him to ring only

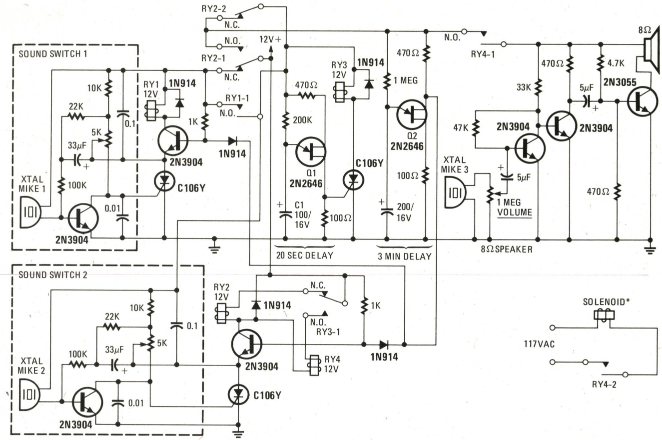


Fig. 1

from the modules and the relays that go together directly to the positive side of the supply. If an external battery is going to be used to supply power, connect these leads to a screw terminal that is insulated from the chassis. If the power supply described for the Teleswitch is used, connect the leads to the positive terminal of the supply. Do the same for all ground leads. Connect all remaining wires to their proper locations.

Cut a piece of 1 × 2-inch wood to a length of 10 inches. This will be used as a vertical support for the solenoid that will hold the phone in the unanswered position until the proper command signal is given. To position the arm, place the telephone on top of the phone cradle where the handset is normally placed. Mark the spot, because that is where you want to mount the arm, and mount the arm using at least two screws. Next, place the solenoid on the inside of the arm and take the handset off the telephone. Position the Bring the wire into the bottom portion of the chassis through a grommet-lined hole and attach one of the two strands to one set of normally open contacts on RY4. Attach another piece of single-conductor lamp cord to the other contact of the set. This wire, along with the unused wire from the solenoid, will be connected to the AC line.

Mount two miniature jacks to the chassis for the microphone and the speaker. The speaker can be acoustically coupled to the telephone by simply holding it next to the telephone mouthpiece with a few rubber bands. The microphone should be located in the spot you want to monitor.

Installation and operation

Installing the Remote Ear simply requires placing the telephone on the chassis, removing the handset and allowing the solenoid to hold the cradle switch down. Now, place the microphone in the room you want to monitor and turn on the once, and then call back 20 seconds later. On his second call, the phone should be answered automatically after the first ring. This is done by RY4, which becomes activated by sound switch 2 when the phone rings the second time. Relay RY4 closes the circuit to the solenoid and causes it to lift up, releasing the cradle switch of the telephone.

Relay RY4 was activated because after 20 seconds had elapsed, Q1 produced a pulse that activated RY3 and switched the power line from RY2 to RY4.

When the call is answered your friend should hear the radio playing. If he does not, check to make sure that the speaker is properly placed next to the mouthpiece of the telephone. Three minutes after the first ring, Q2 generates a reset pulse and releases RY4. This causes the solenoid to drop and hang the phone up. Simultaneously, it opens the circuit to the amplifier. The Remote Ear is now ready to use again. **R-E**

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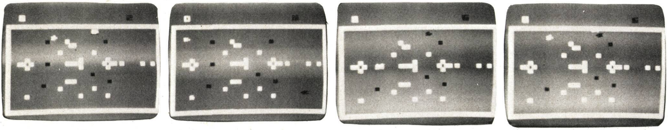

TANK

arcade quality TV game

Part 2. The object is to use your cannon to destroy your opponent first, but watch out for the land mines and anti-tank barriers. The circuit provides a composite video signal to your TV set and produces realistic sound

L. STEVEN CHEAIRS

LAST MONTH, WE PROVIDED THE COMplete schematic of the tank game and discussed in detail the circuit operation.

This month, the article concludes with the foil pattern, component placement diagram and construction details.

Building the game

Before beginning construction, you will need an etched and drilled PC board. You can use the foil pattern in Fig. 4 or purchase the board from the source listed in the parts list. Begin by installing the five jumpers on the drilled board (Fig. 5) and then solder all resistors, capacitors and IC sockets to the board. Next, solder in the diodes, transistors and the regulator IC.

Before proceeding, connect a 12-VAC transformer to the AC input; connect a DC voltmeter across the power-supply pins of the game IC; pin 1 is ground and pin 16 is $+V_{cc}$. Now, apply line power to the transformer—7 volts should be indicated on the meter. If 7 volts is not shown but some value close to it, then a new value for R1 or R2 can be chosen by trial-and-error. If the voltage is drastically different, then a circuit problem exists; use normal troubleshooting techniques to locate and repair the problem.

Next, install the CMOS IC's. Again apply power; using an oscilloscope, adjust the amplitude of the clock at pin 19 of the LSI IC. Remove the power source and discharge the capacitor. Install the AY-3-8700-1 or AY-3-8710-1 IC; the circuit board is now complete. Wire the external components to the PC board (see Fig. 6) and install the unit into a case. If an RF modulator is used, it can be mounted in the case with the PC board or inside the TV set. One last note, the best results were obtained from the prototype with the TV set's contrast control turned up and the brightness control turned to medium-low.

Special considerations

There are several considerations that should be noted for the AY-3-8700-1. First, as the tanks rotate, the shape of their images will vary. Next, the border width will vary from integrated circuit to integrated circuit. Also, the mines could disappear upon interaction with the tanks. When a score is recorded the black tank rotates and the white does not. The 4-second delay makes this effect immaterial. If the tanks exit the screen area, sometimes they will disappear and never return.

For the AY-3-8710-1, the following considerations are important. Upon resetting of the game a random explosion may occur (it may be visible below the bottom border). Also, during the game the gun of either tank may misfire; that is, shells may explode in a spot where the player is not aiming or the shell may not fire from the tank. These do not affect the normal events of the game.

It is possible for a tank to get trapped in a border. When this happens, the game is ended and the other tank is declared the winner. If the barrier interaction switch is

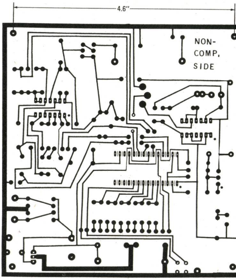

FIG. 4—FOIL PATTERN for the battle game PC board.

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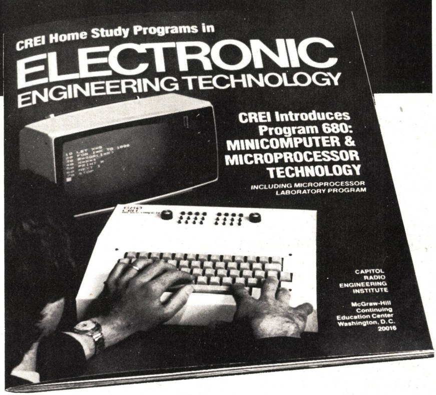

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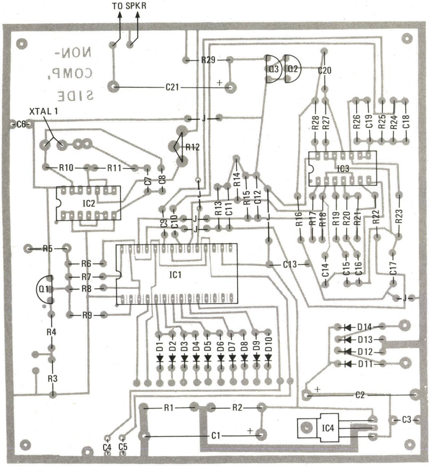

FIG. 5—COMPONENT LAYOUT showing positions of all on-board parts. Switches, speaker and power transformer are mounted in the case.

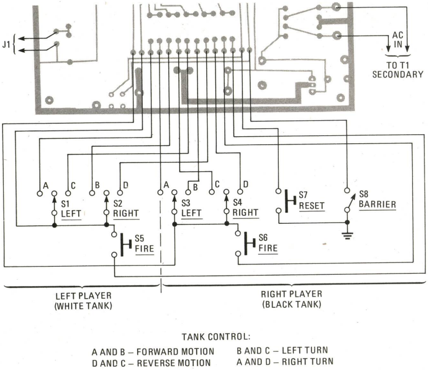

FIG. 6—HOW SWITCHES ARE CONNECTED to the game IC on the board. Lower section of the component side of board is shown for reference.

PARTS LIST

All resistors are ¼ watt, 5%.

R1—180 ohms
R2—510 ohms
R3—470 ohms
R4—1800 ohms
R5—1000 ohms
R6—270 ohms
R7, R16, R19, R20, R23, R28—10,000 ohms
R8—1600 ohms
R9—2400 ohms
R10—12 megohms
R11—220 ohms
R12—5000-ohm, PC-type potentiometer
R13—2.2 megohms
R14—2200 ohms
R15, R21, R26—20 megohms
R17, R22—3.9 megohms
R18—22,000 ohms
R24, R25—10 megohms
R27—30,000 ohms
R29—15 ohms
C1, C2—100μF, 50-volt electrolytic
C3—2.7-μF tantalum
C4–C6, C13, C14—0.1-μF disc
C7, C8—30-pF disc
C9, C10—0.01-μF disc
C11, C12—0.22 μF
C15, C16, C20—5 μF
C17—0.47 μF
C18—200 pF disc
C19—100-pF disc
C21—220-μF, 15-volt electrolytic
D1–D10—1N4148 or similar
D11–D14—1N4005 or similar
Q1–Q3—2N3904 or similar
IC1—AY-3-8700-1 or AY-3-8710-1 LSI game
IC2, IC3—4001, CMOS quad NOR gates
IC4—78M05, 5-volt regulator
J1—miniature open-circuit jack
S1–S4—SPDT center-off, momentary-contact toggle switches
S5–S7—SPST normally open pushbutton switch
S8—SPST switch
S9—SPST toggle switch
T1—12VAC, 1A secondary transformer
XTAL—4.090900-MHz crystal
SPKR—8 ohms
MISC.—12 × 7 × 3-inch aluminum chassis, line cord, hook-up wire, four 1½-inch stand-off busings.

The following parts are available from Questar Engineering Company, McDonald Street, Mesa, AZ 85202: PC board, $12.95; AY-3-8700-1 or AY-3-8710-1 (please specify), $29.00; crystal, $5.50; set of all switches, $12.25. Kit of all parts, $63.95.

selected, the tank cannot drive through barriers. If a tank gets trapped in a barrier, momentarily flip the barrier interaction switch to allow the tank to free itself. Also, sometimes the tanks may get locked together; the only way to separate them is to reset the game. In playing both the AY-3-8700-1 and AY-8710-1 games I very seldom have problems of the type outlined above. These special considerations are presented so that you know what to do in case a problem is encountered. **R-E**

HOBBY CORNER

A look at some clever reader solutions to reader problems.

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

THE TIME HAS COME TO TRY TO CATCH UP on some of the more interesting mail that readers have been sending. I answer letters directly as much as possible, especially if an SASE is enclosed, but there just isn't time to answer all of them. I'd like now just to share some reader ideas with you.

A reader in Puerto Rico makes the point in his letter that he can find published circuits to do everything he has needed so far. These circuits can all be found in manufacturers' data sheets, application notes and various magazines and books. He then says that he would feel pretty silly sending in a circuit obtained from another source, and I agree with him.

Well, it seems to me that although this reader must have a tremendous collection of well-filed and indexed publications there is plenty yet to be discovered. There are many new ways to do old things and new applications for existing components (IC's, etc.).

For example, the lowly 555 has been around for several years now and I would like to have just 1/1000th of a penny for every word that has been written about it. I doubt (although I'm not absolutely sure) that there remains any undiscovered way to make the 555 function as a timer. Quite probably, they all have been discovered and discussed.

Yet, in spite of all that has been written, I am *sure* that many other applications for the 555 remain. Perhaps some are being discovered right now. There are ways to use the 555 that have not yet been dreamed of.

I agree that we should keep up with what is going on by buying all the magazines and books we can find or afford! After all, there is no point in "re-inventing the wheel" every time we begin a construction project. *Someone* is always finding new and better ways of doing things and we should be aware of them.

Recently, I received a letter describing a fantastic reader-built project. There was not a single new device in the project, but the way some of them were used—WOW! I immediately sent the letter to the editor of **Radio-Electronics,** and if things go as planned, that article may appear in **Radio-Electronics**.

So, keep on reading, learning, experimenting and building. There is plenty to be discovered. Even if we don't find anything new, though, trying is more fun than anything else I can think of!

Rocket-launching circuit

A while back (July 1978) we discussed several problems on which readers had asked for help. Well, at least one of those problems hit a nerve. Apparently there are a number of model rocketry buffs or rocketeers among us.

A reader asked for a rocket-launching circuit, and it has been interesting to observe the different approaches that have been developed. Once again this proves that there are many approaches to solving a problem.

One of the best launching circuits was sent in by Tim Coffman (Route 2, Box 448, Liberty, MO 64068). I have given his full address because he wrote that he would be glad to correspond with other readers who are interested in model rocketry.

Unfortunately, there isn't enough space to go into Tim's system in detail. In brief, then, he uses eight IC's and two 7-segment digits to count down to 0, fire the igniter and, finally, count up until rocket touch-down to give the flight time. Three of those IC's are used to detect the 0 count, reverse the counters and start the firing. The timer is the ever-useful 555 operating at 1 Hz.

This rocket circuit is complete with appropriate safety switches and LED status indicators. The count can be placed on HOLD at any time, and the firing is done through an SCR rather than a relay. Altogether, it is a very straightforward circuit.

I must admit I am not a rocketeer. I have had a healthy respect for rockets ever since I saw someone's hand badly damaged by carelessly handled fuel. If you are just starting this hobby, be *very* careful to observe strict safety rules and precautions.

More rockets

A further note about model rockets: I received a letter and catalog from CNA, Box 1252, Lewiston, ME 04240. This company specializes in rocketry electronics with small and large launching systems and other devices. Company president Alfred Celetti recommends that readers interested in model rockets and electronics write the National Association of Rocketry, Box 275, New Providence, NJ 07974.

Super-simple oscillator

A Canadian reader, Guy Isabel, sent in two useful circuits. One is an interesting timer with no moving parts—not even a pushbutton switch. The other is a neat oscillator.

Guy's super-simple oscillator uses four of the six gates in a 7404 hexadecimal inverter plus *one* additional part (see Fig. 1). The output frequency is determined by the value of the capacitor (which should *not* be an electrolytic). As capacitor C is changed from 300 μF to 300 pF, the frequency changes from 1 Hz to 1 MHz.

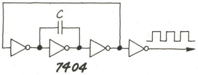

FIG. 1

This oscillator can be used to drive LED's, counters, transistor switches, relays and so on. It could be used as a signal source to test audio amplifiers and certain receivers. In many circuits, it could replace a 555. Used with a switch and several capacitors, it could provide selectable frequencies. And why not use a variable capacitor from an old broadcast radio to cover a range of frequencies?

In addition, Guy Isabel has offered to help those who need circuits for special applications. You can write him at 1725 East, Henri-Bourassa, Apt. 25, Montreal, P. Q. H2C 1J5, Canada.

Low-voltage detector

Hobby Corner received an interesting letter and circuit from Dave Corner of Chicago. Figure 2 is a diagram of Dave's low-voltage alarm circuit.

The values of R1, R2 and D1 are selected for the voltage applied. Using a 12-volt battery, R1 = 10K, R2 = 5.6K and D1 is a 5-volt Zener diode, or a string

of forward-biased silicon rectifiers equaling about 5 volts. Transistor Q1 is a general-purpose UJT (*Uni*junction *T*ransistor), and Q2 is any small-signal or switching NPN transistor.

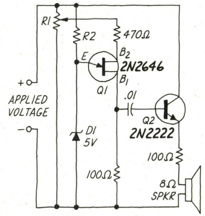

FIG. 2

When this detector is connected across the battery terminals, it draws little current and does not interfere with other devices powered by the battery. If the voltage drops below the trip voltage you have selected with the R1 setting, the speaker beeps a warning. The frequency of the beeps is determined by the amount of undervoltage.

If other voltages are being monitored, select R1 so that it draws only 1 mA or 2 mA (remember E = IR). Zener diode D1 is about one-half of the desired trip voltage, and R2 is selected to bias it at about 1 mA.

Thanks, Dave, for sharing this useful circuit with us.

Solder cream

Multicore Solders has a new line of solder *cream* that comes in tubes like toothpaste. This product doesn't even *look* like solder, but it is and does a beautiful job.

The type of solder useful for your projects is labeled "Ersin . . . for electrical soldering." All you do is squeeze a dab onto a joint and apply heat. For small joints that can't conduct the heat away so fast, the heat source can be a candle, match or cigarette lighter. On larger joints, you should use an iron or torch.

The rosin flux is incorporated in the cream along with the invisible solder. As the cream is heated, it changes to solder and then solidifies to make a good electrical and mechanical joint.

This solder cream is especially handy for use in places that are hard to reach with wire solder. For example, you can coat the end of a wire with cream, insert it into a pin like a phono plug or a PL-259, and then just heat the outside of the pin. It really simplifies the process.

I don't think solder cream will ever replace regular solderwire, but it can perform some jobs more conveniently.

Multicore also manufactures two other types of solder cream, one an all-purpose variety that can be used for many kinds of metals, including stainless steel and silver. It can be used in the place of the acid-flux solderwire that cannot be applied on electrical joints.

The third solder cream is a lead-free cream composed of tin and silver. This cream can be used on stainless steel, silver and other metals; it is also nontoxic.

Solder cream is handy to have around. If you can't obtain it from a local dealer, write to Multicore Solders, Westbury, NY 11590. **R-E**

WE WANT YOUR PROJECT

As you have seen, **Radio-Electronics** regularly publishes construction articles covering all aspects of electronics. If you've just completed an interesting project, tell us about it. If we like it, we'll ask you to become one of our authors and prepare your project as an article. Even if you have never written for a magazine before, this is an opportunity to get your article published and to be paid for your efforts.

Send your proposals to Larry Steckler, Editor, **Radio-Electronics**, 200 Park Ave. South, New York, NY 10003.

computer corner

8085 A look at the software required to control an eight channel analog signal monitor.

C. TITUS, P. RONY, D. LARSEN, and J. TITUS*

IN A PREVIOUS COLUMN, WE DESCRIBED the needs of the 8085 control system and the use of the I/O ports and programmable timer to form an eight channel analog monitor. The necessary initialization of the I/O ports was also discussed. Now we will discuss the software that is necessary for proper operation of the system. It is assumed that the control process is very simple, perhaps just sensing only upper and lower limits of the analog signals.

The programmable timer within the 8155 generates an interrupt every 10 ms.

```
RST75,      PUSHPSW     /SAVE REG A & FLAGS
            MVIA        /CLEAR INTERRUPT FLAG
            020
            SIM
            MVIA        /RE-ENABLE INTERRUPTS
            013
            SIM
            LDA         /GET # OF LOOPS REMAINING
            SEC
            0
            DCRA        /DECREMENT IT BY ONE
            STA         /SAVE IT
            SEC
            0
            JNZ         /IF NOT ZERO, DO ANOTHER LOOP
            NOTYET      /THROUGH THE INTERRUPT
            0
            MVIA        /YES, IT'S ZERO, SO RESET THE SECOND
            144         /COUNTER TO 100 (10 MSEC LOOPS)
            STA         /STORE IT
            SEC
            0
            LDA         /GET THE TIME
            BCDTIM
            0
            STC         /SET THE CARRY FLAG
            CMC         /COMPLEMENT IT TO CLEAR IT
            ADI         /ADD 239 = DECIMAL 99
            143
            DAA         /DECIMAL ADJUST IT FOR A SUBTRACTION OF ONE
            STA         /OF ONE, AND THEN STORE IT
            BCDTIM
            0
            JNZ         /IF THE RESULT IS NOT ZERO, LOOP THROUGH
            NOTYET      /AGAIN
            0

            /ADC SERVICE ROUTINE
            IN          /INPUT THE BCD DATA FROM THE SWITCHES
            201
            STA         /UPDATE THE BCD TIME
            BCDTIM
            0
ADC,        NOP         /THE ADC SERVICE STEPS GO HERE
            NOP
            NOP
            NOP         /ETC.
NOTYET,     POPPSW      /RESTORE REG A & FLAGS
            RET         /RETURN TO MAIN PROGRAM
```

FIG. 1

Since the basic unit of time in this system is a 1-second interval, 100 1-second interrupts must be counted before any action can occur. When the 1-second point has been reached, the program must check to see if it must perform some other action, or continue timing for another 1-second interval. A read/write memory location, SEC, is set aside that will be used to count the 100, 10-ms interrupts. Another location will be required to contain the number of seconds that must be delayed between sampling. Since the thumbwheel-switch data will be entered in binary-coded decimal (BCD) format, you have to decide whether it will be processed in binary or BCD format. We have chosen to process it in BCD format to eliminate a BCD-to-binary code conversion process.

A typical timer control subroutine is shown in Fig. 1. Note that there are steps in this subroutine that clear the RST 7.5 flag and then re-evaluate the RST 7.5 interrupt mask. The information stored in location SEC and BCDTIM has also been used.

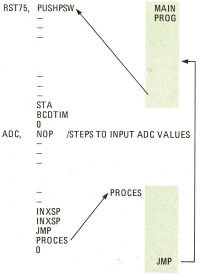

FIG. 2

In our example, it can take up to about 200 μs to proceed through the steps shown, leaving 9800 μs for the remaining program steps. If a slow A/D converter is used to acquire the eight samples, much of the 9800-μs period would be gone, leaving little time in the interrupt-service subroutine before the next 10-ms interrupt occurs. If this happens, the interrupt-service subroutine is interrupted and the computer becomes interrupt-bound. Most A/D converters can perform conversions quickly so this will not be considered further.

We suggest that you acquire the analog

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*This article is reprinted courtesy American Laboratories. Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University. Both Mr. J. Titus and Dr. C. Titus are with Tychon, Inc.

data in the subroutine and then proceed to a data or control-processing section of the program that is *outside* of the interrupt-service subroutine. The control or processing of the program will be interrupted briefly every 10 ms, but it will have up to 1 second to process the old data. It has been assumed that the processing takes less than 1 second. The software example in Fig. 2 shows how the control processing software has been removed from the interrupt-service subroutine. There are other equally valid solutions to this problem. Remember, however, that when you do not intend to use a return address on the stack, you must increment the stack pointer twice to avoid loading the stack with useless information.

This application does not use the serial-in (SID) or serial-out (SOD) connections on the 8085. These connections could be used as a single line-control input and a single line-control output, respectively. They can also be used to serialize ASCII characters for output or to parallel the serial bit stream to reconstruct parallel data bytes. Thus, a software UART could be constructed very easily. **R-E**

ANNUAL INDEX JANUARY—DECEMBER 1978

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NOM CARD FOR 1802
continued from page 48

$\overline{EF_2}$, $\overline{EF_3}$, $\overline{EF_4}$). The flip-flop is reset when the status/output register is read.

The only portion of the interface we have not discussed is the clock—a simple 400-kHz RC oscillator operating between +5 volts and −4 volts, and the hold/reset circuits. The reset circuit is a TTL-to-MOS voltage converter since the reset, hold and oscillator pins are non-TTL inputs. The reset must be held low for at least eight oscillator periods as part of its power-on sequence (8 oscillator periods equals 20 μs). Thus, when the system is powered-up as part of the initialization routine, the reset is set for a minimum of 20 μs, during which time the input-ready flip-flop is clocked three times. The first two times it is set, write an 80_{HEX} to the input port to clear the flip-flop; this is necessary because the hold is set each time the output ready occurs. When the third signal occurs, the NOM interface is ready for its first instruction. If it is not needed at this time, store a 40_{HEX} in the input port. The hold circuit is formed by a TTL-to-MOS voltage converter driven by a 2-input OR gate.

continued next month

service clinic

Trouble with the color and how to localize the problem.

JACK DARR, SERVICE EDITOR

THERE ARE REALLY ONLY THREE COLOR problems and they should be easy to analyze. These are: no color at all, the wrong color and the loss of color sync. These problems originate in three separate circuits—the bandpass amplifier, the 3.58-MHz reference oscillator and the color AFPC (*A*utomatic *F*requency and *P*hase *C*ontrol) circuit. If you check a set and a perfect black-and-white picture appears, this clears everything else in the set!

A complete loss of color can be due to several causes. First, a loss of the color signal itself can be due to a dead 3.58-MHz oscillator, or to faults in the color-killer circuit. To find out which circuit is at fault, feed a color-bar signal into the set and scope the bandpass-amplifier output signal. This signal is normally present at the color control, but it will always appear at the input to the demodulators. If you see a normal "comb" pattern at the right amplitude, the bandpass-amplifier stage is working all right, as well as the killer circuit.

Check for the oscillator signal with a scope. This signal must be at the right amplitude. If the oscillator isn't working, there will be no color.

If you do not see the comb pattern at the bandpass-amplifier output, check all DC voltages, tubes/transistors and pay special attention to the bias on the second bandpass amplifer. This is where the killer bias is used. The DC voltage shown on the service schematic are for no-signal conditions, meaning no color.

The grid will be at a high negative voltage (for a tube circuit; cutoff polarity for a transistor). This voltage should drop to a much lower value when a color signal is fed in. Remember, this is just a plain IF amplifier circuit! If necessary, you can override the killer bias on the grid to check whether the color signal goes through. If so, check out the killer-bias circuitry. This may mean bad diodes, tubes, transistors, or just control misadjustment.

With reference to color alignment, the key word is *don't!* If you must perform alignment, do so only as a last resort and only after finding definite clues that it is needed. Use a sweep curve on your scope to check for misalignment. This will give you a definite clue. However, you should remember that, unless it is very bad, misalignment does *not* cause a complete loss of color, nor will it ever cause a sudden dropout of color. In most cases, alignment is only needed because someone has tampered with the set. Check the scope pattern. If the comb is flat on top and the bars are clean and sharp, it is probably not necessary to align. (Hint—with older scopes, for a clearer pattern use a crystal-detector probe to trace the signals through the bandpass-amplifier stages.) With wideband scopes, use a low-capacitance probe.

If the color oscillator doesn't function at all, this causes a complete loss of color. Some Service Clinic readers write: "My color bars are bluish and greenish, but I can't get any reds!" In quite a few sets, this is because of a dead oscillator. The weak tints observed are because enough of the signal burst leaks through to make the demodulators try to work. The color burst phase is between blue and green. (By the way, this usually means that the demodulators are working!)

The 3.58-MHz signal is critical. A phase shift of only one-sixteenth of *one-cycle* causes blue to change to green, etc.! A working oscillator/AFPC circuit holds the frequency so steadily that this shift seldom occurs. For a network program, a frequency counter on this oscillator should read 3,579,545 Hz. (This frequency is generated by networks using atomic clocks, rubidium and caesium.)

A defective crystal changes the frequency. So far, I have not yet discovered a set that has a dead oscillator due to a bad crystal. If the crystal is just a little off-frequency, the oscillator tends to pull against the AFPC circuit control signal. This makes the color-sync extremely sensitive and prone to fall out with interruptions.

There are two types of oscillator circuits. One is a Pierce oscillator circuit. The crystal controls the frequency, which, in turn, is controlled by the signal burst through the AFPC circuit. Don't be afraid of the AFPC circuit—it basically resembles any horizontal AFC circuit! The oscillator frequency is controlled by a DC voltage developed across a diode pair. To adjust this, kill the AFPC circuit so that the oscillator works independently. Now, adjust the reactance coil, etc., until the colors lock in momentarily. Taking the shunt off the AFPC circuit should lock the color in firmly. If the color falls out of sync, the AFPC circuit isn't operating.

There is one obscure *external* cause for color-sync problems. This is the horizontal oscillator automatic frequency control. In many older sets, this control held the picture in sync over a considerable range. However, at the ends of the control range, the *color* changed hue and fell out. This was due to the change in *phase* of the pulse from the flyback used to gate-out the burst signal. Changing the phase of this pulse far enough results in no signal burst or a very weak burst. Make sure that the horizontal-hold control is centered in its range.

The other type of color oscillator circuit is actually a burst amplifier. This circuit picks off the burst signal and feeds it to a sharp filter, usually a crystal. This causes the crystal to ring; this ring lasts long enough for the next burst signal to arrive. It therefore develops a continuous output that is actually the network signal burst itself. If the gating pulse is out of phase, the burst will not be strong enough to make the circuit work.

In circuits with a reactance-tube AFPC control, this control is actually a voltage-controlled oscillator (VCO). The AFPC diodes develop a small DC-control voltage by comparing the signal burst to the oscillator frequency, similar to horizontal AFC. In many sets, there should be zero voltage on the grid of the reactance tube with the oscillator locked on. (In some, this voltage is offset. Make sure to check the schematic voltage values.) Typical voltage values might range from +5 to −5.

If you run into one with tricky color sync, check to make sure that this voltage "crosses zero" to about the same voltages. This is actually just like any FM discriminator, which it is. Its output signal is an S-curve. If the crystal is just slightly off, you'll probably discover that the grid voltage is either a positive or a negative voltage, but it will not cross zero. It will come down to zero perhaps, and then return in the same polarity. Try a new crystal to see if you can obtain a zero crossing and lock in at 0 volt.

All TV set service data includes com-

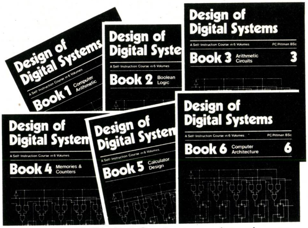
SERVICE QUESTIONS

continued from page 82

open. Also, D101 was bad. I replaced it, but the new one lasts about 5 or 6 seconds and then shorts. Help!—D. W., Feeding Hills, MA.

The picture tube heater circuit in this set uses an instant-on transformer that places 5.0 volts on the tube heater. When you turn the switch on, the *primary* of this transformer is shorted out. In operation, the picture tube heater is fed from a winding on the flyback circuit. (This produces a 15,750-Hz pulse, at about 26 volts P-P, which is equal in *heating effect* to the normal 6 VAC 60-Hz pulse.)

If you used the substitute for D101 recommended in the parts list—RCA SK-3016—this is probably causing your trouble! The RCA SK-3016 is a "sine-wave diode," and the one you need *must* be a fast-recovery type. Try using SK-3175, SK-3515, etc. This applies to *all* sets using DC power supplies derived from flyback pulses. **R-E**



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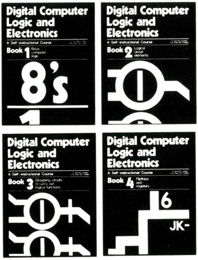

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SERVICE QUESTIONS

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21HB5 horizontal-output grid. When I did this, the bias on the 21HB5 was only −20 volts or so! (I found that I could clamp the pin 5 voltage to −11 and the picture and sound were good.) Why was the voltage so low? Was there leakage in the capacitor? When I checked, capacitor C65 was leaky. I replaced it and bingo! Button this one up.

The second chassis went white in a few minutes and then lost the horizontal drive completely. I followed same circuit; same problem, only heat-sensitive. I replaced C65; no luck. I replaced C66; no luck. Although the 21HB5 tube had been checked and showed good, I didn't change it because I didn't have a new one at the time. So I replaced the 21HB5. Hallelujah! Now the grid bias holds steady at −39 volts, which it should. It wouldn't do this before. So much for AGC problems (which aren't)!

(Congratulations on the persistence and perspicacity, Dave! We have run into quite a few oddball problems like this in horizontal-output tubes in the past few years. In general, it's a good idea to try a new tube and see if this clears the problem. The cause seems to be excessive grid emission (although this is only my opinion). In this case, the analysis became complex until we traced down the source of the negative voltage used to bias the AGC tube. This is a mildly unusual circuit, although quite workable if everything is in good shape.)

FUSE BLOWS VERY FAST

The main power-supply fuse blows very quickly in this Truetone model GEC-4316B. I've checked everything without result! I replaced a few parts, including the horizontal output transistor; no luck. It looks simple but isn't!—D. M., Brunswick, GA.

Here's my favorite remedy: Hook the set up to a variable voltage transformer (variac). Connect an AC ammeter across the empty fuse holder. (If you don't own an AC ammeter, hook up a 0.5-amp pilot light across the fuse holder.) Turn the line voltage up *very* slowly until you notice just a small current flow, or until the bulb lights up a little.

Check the DC power-supply voltages at a point where there should be voltage but it's missing. This solid-state power supply starts to conduct at a very low voltage, which allows you to get data without excessive smoke!

HEATER CIRCUIT OUT

Have I got problems in this Philco model 4C490! The high voltage is 28 kV, there's good sound, the dial lights work, but there's no raster because the picture tube heater is dead! The heater is not

continued on page 84

plete instructions for making color-setup tests, alignment tests and so on. Follow these instructions to the letter. Watch out for deviations; some instructions are different. The tests are usually quite simple; in most, the only instrument you need is a DC voltmeter. Watch the screen to observe what's happening. Color troubles can be easy to troubleshoot if they are approached methodically and logically, one step at a time. **R-E**

service questions

VERTICAL PROBLEM

David Day, of Flori-Day Electronics, Apalachicola, FL, sends these tips along. (He had two Zenith model 14B38Z chassis, both with automatic-gain control (AGC) problems. I suggested some possible cures, including replacing the VDR in the AGC circuit.)

"Here's some feedback for you! I changed the VDR's on both chassis. This didn't help, so I started on the first chassis. I checked all DC voltages around the AGC tube, and found that the voltage on pin 5 of the 8BA11 was only −4 instead of −11. You also suggested tracing the circuit and following it back to the

continued on page 82

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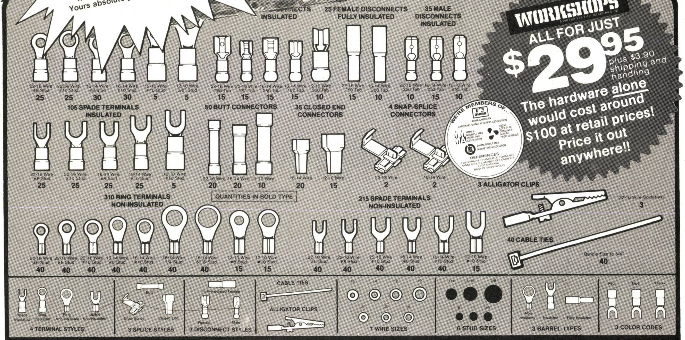

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MAG-1

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C-Meter: MODEL 130

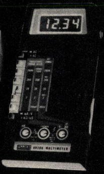
A precision, autoranging, capacitance meter

Autoranging
10 ranges are automatically selected from full scale values of 200 picofarads to 200,000 microfarads, with a maximum resolution of 0.1 picofarads.

Accurate
The C-meter achieves 0.1%(±1 count) up to 200 microfarads and 1% from 200 microfarads to 200,000 microfarads. It is accurate on all ranges at temperatures from 15° to 35°C. (59° to 95°F).

DORIC **$325.**

FLUKE — DIGITAL MULTIMETERS



8010A

- Measures AC/DC Volts, Current and Resistance
- True RMS on all AC Functions
- Diode Test
- In-Circuit Resistance Measurement
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Model 8030A is a 3½ digit, six-function hand-held multimeter with features that qualify it as an excellent field service and troubleshooting instrument. Measurement functions include ac volts, dc volts, ac current, dc current, resistance and diode test. Each function, with the exception of diode test, has five selectable ranges for a total of 26 ranges (one range for diode test).

True RMS conversion techniques offer high accuracy for noise and other distorted waveforms. AC coupling rejects dc bias during ac voltage measurements. DC coupling is used on the ac current ranges to provide the ac and dc capability necessary for measuring power supply and SCR regulator currents.

In-circuit resistance measurements can be made using the normal resistance ranges. Parallel semi-conductor junctions are ignored by impressing less than 200 mV across the unknown resistance.

SPECIFICATIONS

	DC Volts	AC Volts	DC Current	AC Current	Ohms	Diode Test
Range	0.2-1100V	0.2-750V	200μA-2A	200μA-2A	200Ω-2000kΩ	0-2000 mV*
Resolution	100 μV	100 μV	100 nA	100 nA	0.1Ω	—
Accuracy'	(0.1 + 1)	(0.5 + 2)²	(0.35 + 1)	(1 + 2)²	(0.2 + 1)	(0.2 + 1)

8010A $239.

8020A

- 26 Ranges—5 Functions plus New Conductance Function for up to 10,000 MΩ Leakage Measurements
- Extensive Overload and Transient Protection
- Rugged Construction—1 Year Warranty
- Hi/Lo Power Ohms for In-circuit Resistance and Diode Testing
- 10 MΩ AC/DC Input Impedance Doesn't Load Circuit
- 200 Hour, 9V-Battery Life—Low Battery Indicator
- Large LCD Readout—2000 Counts
- 1 Year Calibration Cycle—Only 3 Adjustments
- One Hand Operation
- Complete with Battery and Test Leads

The 8020A has been designed with the user in mind and features exclusive one-hand operation. For harsh service environments, the 8020A has a ruggedized case and extensive overload/transient protection backed up by a 1-year warranty. Long term stability (1-year calibration cycle) is excellent with only three cal adjustments. Up to 200 hours of continuous operation can be expected from a single 9V alkaline battery.

BASIC SPECIFICATIONS

	DC Volts	AC Volts	DC Current	AC Current	Ohms	Conductance³
Range	0.2-1000V	0.2-750V	0.002-2A	0.002-2A	200Ω-20 MΩ	200 nS, 2 mS
Resolution	100 μV	100 μV	1 μA	1 μA	0.1Ω	0.1 nS
Accuracy'	(0.25 + 1)	(0.75 + 2)²	(0.75 + 1)	(1.5 + 2)²	(0.2 + 1)*	(0.3 + 1)*

8020A $169.

New Low Distortion Function Generator

MODEL
3010

- Generates sine, square and triangle waveforms
- Variable amplitude and fixed TTL square-wave outputs
- 0.1 Hz to 1MHz in six ranges
- Push button range and function selection
- Typical sine wave distortion under 0.8% from 0.1 Hz to 100 kHz
- Variable DC offset for engineering applications
- VCO external input for sweep-frequency tests

$144.95

Regular price $175.

B+K PRECISION

B+K PRECISION

520 MHz Frequency Counter

MODEL
1850

- 5Hz to 520 MHz reading guaranteed —600 MHz typical
- Gate time from 10ms to 10 seconds
- Full period measurement capability
- 50 mV input sensitivity at 520MHz
- Operates from 115 or 230 VAC, or 12 VDC
- Well protected input circuitry
- Temperature compensated crystal oscillator (TCXO)

$379.95

Regular price $450.

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MULTIFUNCTION COUNTERS

DISTINCTIVE PERFORMANCE FEATURES YOU CAN USE

The 1910A, 1911A And 1912A Family

Precise, rapid determination of frequency, period and period-average, coupled with totalize capability, represent superior versatility and performance in the Fluke 1910A, 1911A and 1912A multicounters. Here are the features and benefits that distinguish these hard working counters from all others in their price range.

Multifunction

The family does the work of counters costing much more. They measure frequencies to 125 MHz (1910A), 250 MHz (1911A), and 520 MHz (1912A); period of signal frequencies to 2 MHz.

Autorange

Full autoranging is supplemented by selectable four-range manual operation. In autorange, the display is automatically filled to a maximum 7-digit readout.

Input Signal Conditioning

All three counters offer trigger level and attenuator controls which operate over the dynamic range of the input to permit *accurate readings in the presence of noise.*

Automatic Clean Dropout

The 1911A and 1912A Channel B input has a circuit which automatically monitors the input and gives you instant warning in the form of zero readout whenever your input signal level falls below the sensitivity threshold of the trigger circuit. When the signal level returns to an acceptable level, the counter locks on for a correct reading. *When you get a reading, you know it's right.*

Sensitivity

A basic sensitivity of 15 mV, backed by Fluke's conservative design margin, guarantees you will get reliable, solid readings every time. In practice, a typical sensitivity of 10 mV will be experienced.

Autoreset

This automatic feature is activated every time you select a new range or function, which means you never have to wait for a second reading, the first one in the new measurement sequence is always correct. *Autoreset saves time and reduces errors.*

125 MHz	**1910A $395**
250 MHz	**1911A $495**
520 MHz	**1912A $620**

FLUKE®

SPECIFICATIONS

Input Characteristics

Model	Channel	Operating Range: Frequency	Operating Range: Period	Sensitivity
1910A	A	5 Hz - 125 MHz	500 ns - 0.2s (5 Hz - 2 MHz)	15 mV rms, 5 Hz - 100 MHz 25 mV rms, 100 MHz - 125 MHz
1911A	A	5 Hz - 125 MHz	500 ns - 0.2s (5 Hz - 2 MHz)	15 mV rms, 5 Hz - 100 MHz 25 mV rms, 100 MHz - 125 MHz
	B	50 MHz - 250 MHz		15 mV rms, 50 MHz - 175 MHz 30 mV rms, 175 MHz - 250 MHz
1912A	A	5 Hz - 125 MHz	500 ns - 0.2s (5 Hz - 2 MHz)	15 mV rms, 5 Hz - 100 MHz 25 mV rms, 100 MHz - 125 MHz
	B	50 MHz - 520 MHz		25 mV rms, 50 MHz - 520 MHz

LEADER Instruments Corp.

LCR-740
Transistorized LCR Bridge

- Highly accurate 3 digit readout.
- Measures Inductance (L), Capacitance (C) and Resistance (R), within ±0.5% accuracy.
- Range expandable — built-in 10% over range.
- Loss Factor scale (D).
- Battery, or AC adapter operation.

$279.95

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LCG-395
SOLID STATE VIDEO COLOR SIGNAL SOURCE

LEADER Instruments Corp.

- Provides staircase, window, convergence and white purity adjustments.
- Multi-purpose applications for CATV, MATV, CCTV, VTR and NTSC testing.
- Segment display information provides data details for every color check requirement.
- Exclusive convergence check facility gives hztl and vert'l lines and dots within 80% safety margin.
- 5-step staircase signal for checking modulation levels in 20% segments from 0 (black) to 100% (white).
- Window and noiseless white raster position.
- 10 gated rainbows, plus 3 gated color bars; plus overall rainbow pattern.
- Return trace blanking for vert/hztl signals.
- 2 switch selectable RF chan. frequencies.

$199.95 $299.95 Regular price

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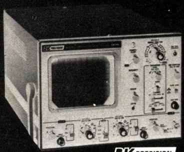
Dual-Trace 5" 30MHz Triggered Scope...



MODEL
1474

- Rise time 11.7 nS or less
- Built-in signal delay line permits view of leading edge of high frequency pulse rise time
- Triggers on signals up to 50 MHz
- 5mV/cm vertical sensitivity
- Mode automatically shifts between CHOP and ALTERNATE as you change sweep time
- Checks most digital logic circuitry, including ECL
- High accuracy ten position vertical input attenuator
- Flat response with smooth rolloff past 30 MHz
- PDA CRT with P31 phosphor
- Built-in high- and low-pass filters
- Maintains calibration accuracy from over 105-130 VAC and 205-260 VAC
- 20 calibrated sweeps—0.2 μS/cm —0.5 S/cm

$729.95

B+K PRECISION

Probes not included in price

LBO-520
30MHz, Fixed Delay

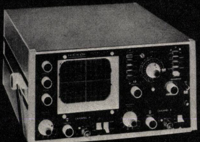
LEADER Instruments Corp.

- Dual trace, 30MHz bandwidth.
- 5mV/cm Vertical Sensitivity.
- Fixed delay facilitates hi-speed readings of the leading edge of a pulse or pulse train.
- Add, subtract, alternate selection, chopped, and front panel X-Y modes broaden areas of application.
- TV-V and TV-H sync. for both CH-1 & 2.

$849.95

Regular price $1,050.

Model 517 Dual-Trace 15 MHz Triggered Oscilloscope



HICKOK

$589.95

Regular price $695.

- 15 MHz response flat within 3dB for all signal levels. Excellent pulse response minimizes overshoot and ringing.
- 5mV/cm sensitivity, useful for solid-state work.
- Foolproof triggering to 27 MHz (30 MHz typical).
- X-Y operation for vectorscope measurements.
- Bright 8 cm x 10 cm display.
- Auto mode triggering provides baseline for recurrent sweep operation.
- CHOP or ALTERNATE mode automatically selected as sweep time is changed for speedy setup.
- Algebraic sum and difference capability.
- Differential input capability.
- Digital logic circuit capability, including CMOS.
- Analyze CB AM and SSB waveforms.
- TV sync separators built in.
- Regulated power supply maintains amplifier gain with changes in line voltage from 105 to 125 volts.

LBO-508
20MHz, Dual Trace

LEADER Instruments Corp.

- Add, subtract modes on CH-1 & CH-2 facilitate easy checkout for simultaneous pulses, signal levels, distortion & noise cancelling.
- Front panel X-Y operation useful for phase shift measuring, sweep alignment, vector scope service.
- 17.5nSec rise time.
- Automatic chop and alternate selection for low and high frequency checks.
- Automatic trigger for CH-1 or 2 includes TV sync.
- 10mV. to 20V/cm Vertical Sensitivity; 11 steps.
- 0.5μS/cm to 200mS/cm sweep speed; 18 steps; X5 magnification.

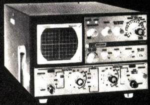
$614.95

Regular price $769.

SUPER SPECIALS

Shipping not included in prices Sale ends Dec. 31, 1978

New 15MHz portable 3" dual-trace scope

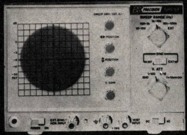


MODEL
1432

- 15MHz bandwidth with smooth roll-off; usable response extends beyond 30MHz
- 2mV/div. vertical sensitivity
- Operates on 117VAC, 234 VAC, 12VDC or optional internal battery pack
- Fully regulated high- and low-voltage supplies
- Algebraic addition and subtraction of Channel A and B input signals
- Nineteen calibrated sweep ranges cover 0.5 microsecond to 0.5 second
- TTL Compatible Z-axis input
- Compact size; measures only 5.5 x 8.25 x 14.3"
- Includes two slim-body 10:1/direct probes and accessory tips
- Built-in sync separators

B+K PRECISION

$629.95 Regular price $780.



5MHz Solid State 3" Oscilloscope

MODEL
1403A

B+K PRECISION

- 5 MHz with high sensitivity
- For production lines, schools, field service work, hobbyists
- CB modulation monitor
- Ultra-compact and lightweight; goes anywhere!
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- Vertical sensitivity of 10mV/division.
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3-1/2 Digit DMM with .5% Accuracy

B+K PRECISION

MODEL
2810

$109.95

Regular price $130.

- 3½ digit easy to read LED display
- 0.5% DC accuracy typical
- 100μV, .01Ω resolution
- 10 ohm range and control to zero lead resistance
- Selectable High-/Low-power ohms on four ranges
- Auto zeroing
- Completely overload protected on all 29 ranges
- 100% overrange reading to 2000 counts full scale
- Protected against RF interference
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FR

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New
Computerized Weather Monitor

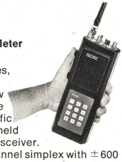
If you need weather information for ANY purpose, the ID-4001 is the way to get it! This microcomputer-based weather instrument digitally displays—time of day in 12 or 24-hour format; wind direction and magnitude; indoor and outdoor temperature; barometric pressure; even wind chill factor! What's more, the computer's memory stores the highest and lowest data for each function so you can recall it for easy and accurate record keeping. Chart recorder and computer outputs provide even more versatility!

Includes remote transmitter with windcups and weathervane that have been wind-tunnel tested and an outdoor temperature sensor using the latest infra-red technology.

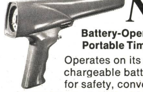
New
Digital Readout Car Clock with Trip Timer

Versatile clock/timer for any vehicle shows time in hours and minutes, has 24-hour timer that reads to nearest second. Bright, easy-to-read display, low-power circuit doesn't drain battery.

New
Hand-Held 2-Meter Transceiver



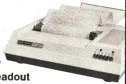
Superb features, specifications and a great low price make the VF-2031 a terrific buy in a hand-held two-meter transceiver.
Features 8-channel simplex with ±600 kHz offset using one crystal per channel, minimum 2 watts out, and 0.5 μV sensitivity for 20 dB quieting. Includes built-in antenna, nickel-cadmium batteries and battery charger. An optional tone encoder and other accessories are also available. Units will be available in January, subject to FCC approval.



New
Battery-Operated Portable Timing Light

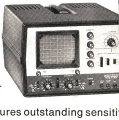
Operates on its own rechargeable batteries for safety, convenience and complete portability. Ideal for use on boats or other vehicles where battery may be inaccessible. Also features dual-range tachometer, rugged pistol grip, extra-bright xenon tube for easy-to-see timing flashes.

New
WH14 Line Printer for "Hard Copy" Computer Readout



Low-cost microprocessor-controlled l printer is designed to give you a convenient "hard copy" printout of your computer programming. It eliminates losing and recalling program lines aft they have scrolled off a CRT, it also pr vides handy printed lists of address lines, lists or other program data for e editing and manipulation. Prints the standard 96-character ASCII set (upp AND lower case) on a 5x7 dot matrix p head. Designed for use with Heathkit computers and others as well. Availab fully assembled and tested only.

New
Low-Cost Dual-Trace Oscilloscope



Low-priced dual-trace scope ideal for audio and TV servicing. Features outstanding sensiti extra-bright traces, selectable triggeri 7-position variable time base, DC to 5 MHz bandwidth.

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Portable Room-Size Electronic Air Cleaner

An important addition to any household – it removes dust, and pollutants from any room in r house while cleaning and refresh- he air – and all for just pennies y. It's especially important for lated and tightly sealed houses re air can get "stale" after parties, king, etc. Features 3-way cleaning ration to remove both large and ll particles and household odors. able speed control that lets you ick-clean" a room, then lower the ed to maintain a fresh air level. dsome Southern-Pecan vinyl finish inet blends nicely with any decor. y NO SOLDER kit assembly too.

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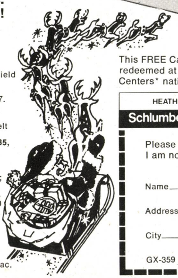
CONSIN – Milwaukee, 53216, 5215 W. Fond du Lac. 873-8250.



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CIRCLE 100 ON FREE INFORMATION CARD

Designing Digital Circuits
Continued from page 66

entry in the group below it, seeing if the differences in parentheses are the same (though they may be in any order), and seeing if the difference of the first numbers is a power of two. Indicate the end of the check of each group by a horizontal line in the next column, to show a new group there.

We now have a list of cubes that cover the 1-output boxes, similar to the cover created in the Karnaugh map. However, using the Karnaugh map, one can visually inspect to obtain the largest cubes to cover each 1-labeled box. This is not the case using the Q-M method, so a "cover map" must be drawn. On this map, we draw vertically the decimal equivalents of the cubes that are left unchecked in Fig. 12, and draw horizontally the decimal equivalent of each input that is to produce a 1 (but not a don't-care) output (see Fig. 13). A check is now placed in each box of the table under the column that is covered by a given row, i.e., the row labeled 4,12 has a check in columns 4 and 12.

	4	8	9	12	13	14
4,12	✓			✓		
12,14				✓		✓
8,9,12,13		✓	✓	✓	✓	

FIG. 13—COVER MAP is obtained by listing the decimal equivalents of the unchecked cubes from Fig. 12.

Now we look at each column to see which rows are needed. We see that the column labeled 4 has only one check, in row 4,12. Thus row 4,12 (i.e., the term corresponding to 1-cube 4,12, as in the Karnaugh map) is essential to obtain an output of 1 when 4 is input, so we place a check by row 4,12. We then place a check above the columns numbered 4 and 12 to indicate that these have been covered. Column 8 has only one check, indicating row 8,9,12,13 is essential. A check is placed by this row and above columns 8, 9, 12 and 13. The only uncovered column is 14, which can only be covered by row 12,14. That row and column 14 are checked. The map now appears as shown in Fig. 14.

		✓	✓	✓	✓	✓	✓
		4	8	9	12	13	14
✓	4,12	✓			✓		
✓	12,14				✓		✓
✓	8,9,12,13		✓	✓	✓	✓	

FIG. 14—ESSENTIAL ROWS are determined and then confirmed by placing a check next to them.

All columns with only one check in them should be handled first in this manner. For the remaining unchecked columns with more than one table entry check, choose the largest possible cubes to cover the most unchecked columns. In this manner, the function will be completely reduced. In any case, all columns must have a check above them when done, so that all output situations are covered. Any rows that do not have a check beside them are eliminated.

The remaining rows (those with a check to the left of them) then correspond to the inputs to each of the gates. To determine the inputs, the decimal numbers in the labels of each row are written in binary, and the input bits that do not change between the numbers are the inputs to the gate. For example, Fig. 15 illustrates that for row 8,9,12,13, bit a_1

	a_1	a_2	b_1	b_2
8	1	0	0	0
9	1	0	0	1
12	1	1	0	0
13	1	1	0	1

FIG. 15—TRUTH TABLE of final function is shown.

must always be on, and bit b_1 must always be off, while a_2 and b_2 may be either 0 or 1, to generate a 1-output for this term of the expression. Thus, the output is 1 if $a_1\bar{b}_1 = 1$. Similarly, row 4,12 indicates a 1-output if $a_2\bar{b}_1\bar{b}_2 = 1$, and row 12,14 indicates a 1 output if $a_1a_2\bar{b}_2 = 1$. Our final function is thus:

$$f = a_1\bar{b}_1 + a_2\bar{b}_1 1\bar{b}_2 + a_1a_2\bar{b}_2$$

This function is implemented as shown in Fig. 16.

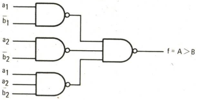


FIG. 16—LOGIC CIRCUIT implementation of truth table shown in Fig. 15.

Next month we will discuss multiple-output functions and sequential circuits along with cover maps and truth and state tables used in digital circuit design. **R-E**

"Don't let on you know—but actually it's just a simple project requiring the plugging of a few units into a prewired PC board."

SPEAKER CABLES
continued from page 62

patches, etc., because they deteriorate the quality of the audio signal. M & K claims its cable has an inductance that is 12 times lower than No. 12 zip cord and comparable resistance.

The Fulton cable uses silver-plated wire; the tips are finished off in spade lugs; 30-foot sections of No. 16 wire cost \$1.34-per-foot; and No. 12 cable costs \$2.60-per-foot.

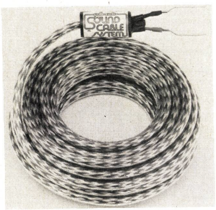


FIG. 6—POLK AUDIO SPEAKER CABLE consists of 144 strands of low-resistance wire braided into two sets of conductors at right angles to each other.

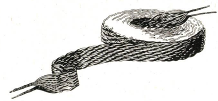


FIG. 7—AUDIO SOURCE's *High Definition* cable, with 10-ohm impedance, has 10 pairs of braided wire, connected in parallel and with special tips.

The Polk cable comes in a round version (see Fig. 6) at \$1.34-per-foot; in four different lengths, up to 50 feet; and is claimed to have a characteristic 9-ohm impedance. The Polk cable consists of 144 strands of separately insulated, low-resistance wire braided into two sets of conductors that constantly lie at right angles to each other to avoid inductance.

All the braided cables are arranged this way because it is claimed that this eliminates interference between the adjoining magnetic fields, thus minimizing self-inductance. In addition, the two polarities are brought as close as possible to each other to insure minimal and correct characteristic impedance.

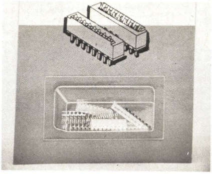
The *Mogami* cable's stacked arrangement has an inner core of nonconductive material for spacing and extra strength; a final conductor layer has 60 strands of wire about equal to No. 11; a layer of insulation made of tough synthetic material; and another conductor layer wound

continued on page 102

new products

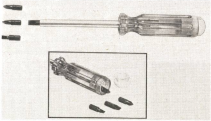
More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside back cover.

DIP SOCKET low-profile unassembled Molex sockets available in 14-pin and 16-pin versions. IC DIP sockets come in display card package containing four terminal carrier strips and four IC nests. When assembled, components form two complete DIP sockets whose terminals are made of 70/30 spring-tempered tin-plated brass. Assembly instructions are given on the back of the card. Socket assemblies are available from Waldom distributors. Prices: parts for two 14-pin sockets, 95¢; two 16-pin sockets, $1.—**Waldom Electronics, Inc.,** 4301 W. 69th St., Chicago, IL 60629.



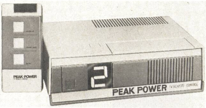
CIRCLE 114 ON FREE INFORMATION CARD

MAGNETIC SCREWDRIVER, *model 70035,* has magnet built into the shank to hold interchangeable bits plus the screw. *Confordome* handle has a removable dome cap that keeps three extra bits stored inside handle while fourth bit is being used. Comes with 3/16-in. and 9/32-in. slotted, No. 1 and No. 2 Phillips bits.—**Vaco Products,** 1510 Skokie Blvd., Northbrook, IL 60062.



CIRCLE 115 ON FREE INFORMATION CARD

WIRELESS REMOTE CONTROL, *model GP-500,* attaches to the antenna terminals of any black-and-white or color TV set. The unit's 10-channel capacity is tunable to either VHF or UHF, and each channel can be preset. A built-in RF preamplifier has a power gain of 30 dB (typical). Other specifications include: Maximum noise—90 dB (VHF) and 12 dB (UHF); IF rejection—40-dB minimum (VHF) and 60-dB minimum (UHF); minimum image rejection—50 dB (VHF) and 40 dB (UHF); input impedance—75 ohms; tuner frequency bands—55.25 to 83.25 MHz, 175.25 to 211.25 MHz (VHF); 471.25 to 888.25 MHz (UHF). The *model GP-500* components are encased in two-tone high-impact plastic; the receiver measures 6 × 10¼ × 3⅛ inches; the transmitter measures 2½ × 5¾ × 1 inch. Suggested list price: $99.95.—**GP Electronics, Ltd.,** Subsidiary of Gold Peak Industries, Ltd., Box 261, Middletown, NJ 07748.

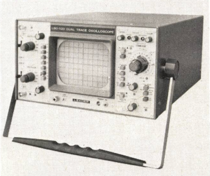


CIRCLE 116 ON FREE INFORMATION CARD

SOLDER STRIP PACKAGE, *Emergency Solder,* is designed for on-the-spot repairs and requires only a match to melt the solder. Multiple cores of noncorrosive, nonconductive flux are contained in the strips. *Emergency Solder* can be used on any solderable metal (not suitable for aluminum). Package includes 36 inches of solder strip, and complete directions.—**Multicore Solders,** Westbury, NY 11590.

CIRCLE 117 ON FREE INFORMATION CARD

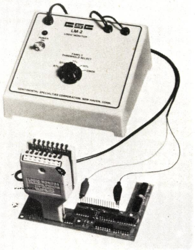
DUAL-TRACE 30-MHz OSCILLOSCOPE, *model LBO-520,* offers built-in 120-ns delay line. Among the unit's other features are a 5 mV-per-division vertical sensitivity; display modes include Channel 1, Channel 2, alternate, subtract, add and X-Y modes; continuously variable sweep speeds from 0.2 μs-per-centimeter to 0.5 second-per-centimeter; ×10 magnification. In addition, the *model LBO-520* provides trace rotations; + and − polarity; an uncalibrated warning indicator lamp; and lever-type input switches. Priced at under $1000, the instrument comes with contoured



handle that doubles as locking bale; probes and accessories are included.—**Leader Instruments Corp.**, 151 Dupont St., Plainview, NY 11803.

CIRCLE 128 ON FREE INFORMATION CARD

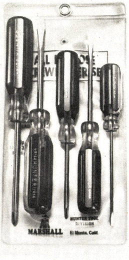
LOGIC MONITOR, *model LM-2*, is a self-powered unit that clips right onto IC under test; a series of 16 LED's at top of the clip follow IC pin pattern. A rotary switch selects the proper logic threshold



for monitoring RTL/DTL, TTL/HTL and CMOS circuits. A separate cable for CMOS circuits uses the circuit voltage to determine the logic level and operates up to a 30-kHz input frequency at 50% of duty cycle. The *model LM-2*, with self-contained 117 VAC 50- to 60-Hz power supply, is priced at $129.95. A 220 VAC 50- to 60-Hz model is also available.—**Continental Specialties Corp.**, 70 Fulton Terrace, New Haven, CT 06509.

CIRCLE 129 ON FREE INFORMATION CARD

SCREWDRIVER SET, *model 31802*. Five-piece mechanic's screwdriver set comes packaged in heavy vinyl pouch. It contains one ⅛ × 4-inch blade (⅞ × 2¾-inch handle); 3/16 × 4-inch blade (1 × 3¾-inch handle); ¼ × 4-inch blade (1⅛ × 4¼-inch handle); 3/16 × 3-inch blade with No. 1 tip



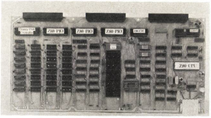
(1 × 3¾-inch handle); and ¼ × 4-inch blade with No. 2 tip (1⅛ × 4¼-inch handle). Screwdrivers are made of chrome vanadium steel, with cross-ground tips and easy-grip handles. Suggested resale price, $7.63.—**Hunter Tools,** 9674 Telstar Ave., El Monte, CA 91731. **R-E**

CIRCLE 130 ON FREE INFORMATION CARD

computer products

More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside back cover.

Z80 COMPUTER BOARD, *90F/MPS,* is a Z80-based, single-board device with resident floppy-disc controller that supports up to four 5¼-inch or 8-inch single-density floppy-disc drives. The basic board contains 4K bytes dynamic RAM (expandable to 64K bytes); six 2708/2716 EPROM sockets; 1K byte resident PROM monitor



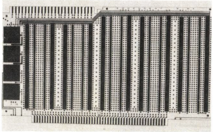
with static RAM scratch pad; PROM programmer; counter/timer; hardware UART with RS232C/TTY serial I/O; plus a programmable 8-bit parallel I/O port with two expansion sockets for additional PIO IC's. Prices: single unit, $995; OEM discounts available.—**Quay Corp.,** Box 386, Freehold, NJ 07728.

CIRCLE 121 ON FREE INFORMATION CARD

COMPUTER PRINTOUT PICTURES are now available in a 23-picture set printed on 58 14⅞ × 11-inch sheets. The set includes four pictures of Snoopy, five Christmas scenes, Abe Lincoln and others. Price: $7.75.—**Data Analysis Systems,** Dept. F, Box 162, Franktown, CO 80116.

CIRCLE 122 ON FREE INFORMATION CARD

PROTOTYPE BOARD is a two-sided wire-wrap board that comes in kit form, complete with layout, instructions, 4 matching heat sinks plus hardware mounting, and 2 yards of AWG No. 18 wire. One side of the 10 × 5.5-inch board is fully S-100-bus compatible with 100 contacts spaced at 0.125-inch intervals. The board's other side has 50 contacts spaced at 0.156-inch intervals for the SS-50 bus but is only electrically compatible with the SS-50 bus. An SS-50 bus extender board is also available with a 22-slot maximum



capability (no edge connectors are provided). The board accepts from 14- to 40-lead DIP packages, and additional space is provided for up to 26 or more resistors or transistors. The board also has provision for three-way keyed mounting, 2 card ejectors, filter capacitors for the voltage regulators and transient suppressor capacitors at approximately 6-inch spacing. Prices: kit, $29.95; SS-50 bus extender board, $49.95; edge connectors available separately.—**AUM-Ideas,** Box 2582, Richardson, TX 75080.

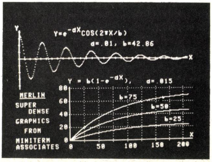
CIRCLE 123 ON FREE INFORMATION CARD

COMPUTER SYSTEM, *PeCos I,* is a complete personal computing system that does not require hookup to any RF adapters, TV sets, audio cassettes, etc. It provides 24K ROM and 16K RAM; a 60-key keyboard with upper and lower case; a 9-inch CRT displaying 16 lines of 40 characters each with automatic scrolling and speed control; built-in dual cassette decks, each with 80K byte storage capability; 6502 microprocessor; power supply; and RS 232 port for connecting a printer. Software is implemented in PeCos, an English-like language derived from Rand JOSS; and includes full 9-digit floating point

arithmetic computation. The unit measures 18½ × 19½ × 8½ inches. Suggested retail price: $1695.—**APF Electronics, Inc.,** 444 Madison Ave., New York, NY 10022.

CIRCLE 124 ON FREE INFORMATION CARD

GRAPHIC/TEXT VIDEO DISPLAY INTERFACE, *Merlin,* comes assembled and tested, or as a kit. It can be used to interface to any S-100 bus computer and provides 4K bytes of ROM, keyboard input port, plus text and graphic displays. The text display consists of 20 lines, 40 characters-per-line, suitable for BASIC and assembly programs. The medium-resolution bit-mapped

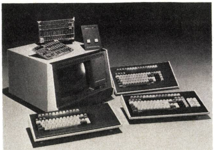


graphic display is 160H by 100V with expansion to 320H by 200V using super-dense graphic option.

The keyboard contains the following modes: edit function, scrolling, monitor, 25 cursor/edit functions, graphic subroutines and graphic drawing. The display address and display mode (text, graphic or "split screen") are software-programmable. Prices: assembled (with 4K ROM control and super-dense graphic option) $499.95; kit (without ROM software) $299.95.—**MiniTerm Associates, Inc.**, Dundee Park, Andover, MA 01810.

CIRCLE 125 ON FREE INFORMATION CARD

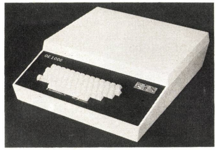
PROGRAMMABLE TERMINAL SYSTEM, *EXOR 68,* is multifunctional—consists of basic display unit with 12-inch CRT, six keyboard options and a group of micromodule subassembly boards. The CRT display unit consists of video monitor that can display 128 ASCII characters in 24 lines (up to 1920 characters); switches select word length, baud rate, communications mode and modem



control. Other features include inverted cursor, scrolling and page/edit/protect display modes; remote or keyboard data entry capability; and optional motherboards. Basic display unit is available separately for end applications without keyboards. Keyboard options include Standard TTY/control key format plus 5 other variations. End-use micromodule options range from partial computers (memory, interface, etc.) to complete single-board assemblies; all are compatible with *EXOR 68* system. Basic display unit with extended communications and display features plus keyboard and cable assembly sells for $2600 (approx.) in single quantities.— **Motorola Microsystems,** 3102 N. 56th St., Phoenix, AZ 85018.

CIRCLE 126 ON FREE INFORMATION CARD

COMPUTER TERMINAL, *model OE1000,* comes as a kit or assembled, and interfaces to any computer having a 300-baud serial data output port. It offers the full duplex mode with either a 20-mA current loop or an RS 232 voltage swing. Displays 96 ASCII characters and 32 special characters in a 16-line by 64-character format,



with either upper and lower case or TTY modes. Other features are full cursor control, automatic scroll, erase to end of line, erase to end of screen and clear screen. Prices: kit, $275; assembled, $350.—**Otto Electronics,** Box 3066, Princeton, NJ 08540. **R-E**

CIRCLE 127 ON FREE INFORMATION CARD

stereo products

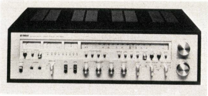
More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside back cover.

DIRECT-DRIVE TURNTABLE, *model PS-TI,* is a semiautomatic unit that features a linear-torque, brushless, slotless DC servomotor with ring-shaped magnet and fixed coil. The speed-monitoring system consists of a magnetic coating on outer rim of the platter, which is tracked by a magnetic head to detect speed variations. Other

features include a J-shaped tonearm (statically balanced to provide 7–9-Hz resonance), counterweight with stylus pressure gauge, antiskating device, safety clutch, reject button and illuminated strobe. Suggested list price: $130.—**Sony Corp. of America,** 9 W. 57th St., New York, NY 10019.

CIRCLE 113 ON FREE INFORMATION CARD

AM/FM STEREO RECEIVER, *model CR-3020,* incorporates preamp containing peak-reading meters, coil-head amplifier, signal meter, LED display and two headphone jacks (with separate



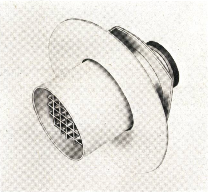
volume control). General specifications: continuous RMS power, 200 watts-per-channel (at 4 ohms, 0.05% THD); 20-Hz–20 kHz THD (phono 1 & 2 to record output), 0.003% at 5 volt output; input sensitivity (phono 1), 2 mV; frequency response (aux, tape 1 & 2 to speaker output) 5 Hz–100 kHz, −3 ±2 dB; S/N ratio (phono 1 & 2) 96 dB (10-mV input).

FM section: usable sensitivity at 300 ohms, 11.2 dBf; 50-dB quieting (mono) 15.3 dBf, (stereo) 37.2 dBf; IHF distortion (stereo), 0.1% (local), 0.6% (DX). AM section: 1000-kHz selectivity, 45 dB (±10 kHz), 35 dB (±9 kHz).

The *model CR-3020* comes in an ebony cabinet, measures 24¾ × 7½ × 19½ inches and weighs 81 lb, 8 oz. Price: $1400.—**Yamaha International Corp.,** 6000 Orangethorpe Ave., Buena Park, CA 90622.

CIRCLE 112 ON FREE INFORMATION CARD

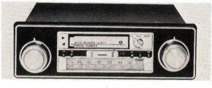
CEILING SPEAKERS, *models DK5-F, RS69-F* and *RSQ8-F* are made of acrylic plastic and feature cloth-roll suspension, 1½-lb magnet construction and an aluminum voice coil. The speakers are easily mounted and come with complete mounting instructions. The *model DK5-F* (shown) is a 5-inch two-way speaker with a 360° swivel tube for directional sound and a decorative grille; its specifications include a 48-Hz–20-kHz frequency response, 8-ohm impedance, 65-Hz resonant frequency and 25-watt power handling capability. The *model RS69-F* is a 6 × 9-inch two-



way recessed round speaker with a 35-Hz–19,500-Hz frequency response, 8-ohm impedance, 50-Hz resistant frequency and 40-watt power handling capability. The *model RSQ8-F* is an 8-inch two-way recessed square speaker with a white exterior and chrome grille. Its specifications are: a 28-Hz–21-kHz frequency response, 8-ohm impedance, 50-Hz resonant frequency and 45-watt power handling capability. List prices: *model DK5-F,* $54.95; *model RS69-F,* $64.95; *model RSQ8-F,* $69.95.—**Rohn Electronics, Ltd.,** 5 Pearsall Ave., Glen Cove, NY 11542.

CIRCLE 111 ON FREE INFORMATION CARD

AM/FM TAPE CAR STEREO, 8-track *model 873* and cassette *model 633,* both deliver 20 watts-per-channel RMS; the tuner sections feature FET frontends and PLL circuitry in the multiplex

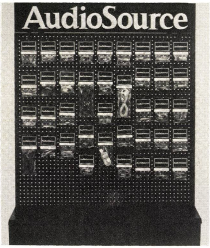


decoder, plus local/distance switch and FM muting. The *model 873* player had indicator lights and a dial-in-door cartridge slot. The *model 633* cassette player (shown) provides automatic reverse, pushbutton eject, locking rewind/fast forward switches, plus tape direction indicators.

Both units contain bass/treble, balance/fader, and volume/loudness controls. Suggested retail prices: *model 873,* $209.95; the *model 633,* $244.95.—**J.I.L.,** Dept. P, 737 W. Artesia Blvd., Compton, CA 90220.

CIRCLE 106 ON FREE INFORMATION CARD

HI-FI CABLES/CONNECTORS, full line of stereo cables and connectors for all systems. Product line includes 2-pin DIN speaker, line plugs and sockets; 3- and 5-pin DIN plugs and sockets; leads with either RCA or DIN plugs and sockets in



different lengths and configurations; leads with combined RCA/DIN plugs or sockets; a headphone extension cable; and an FM dipole antenna.—**AudioSource,** 1185 Chess Drive, Foster City, CA 94404.

CIRCLE 110 ON FREE INFORMATION CARD

books

MICROCOMPUTER HANDBOOK, by Charles J. Sippl. Petrocelli/Charter, Div. Mason/Charter Publishers, Inc., 641 Lexington Ave., New York, NY 10022. 454 pp. 6½ × 9½ in. Hardcover $19.95.

This book is designed to serve the needs of designers, students, hobbyists and all those who require a thorough understanding of low-cost microminiaturized computer systems. Systems engineers and developers who must integrate these computers into existing systems will also find this book a useful guide.

Early chapters deal with and contrast standard computers and minicomputers. Other chapters describe the various types of microcomputers and their capabilities, software, programs and many applications. All terminology is carefully defined, and photos and diagrams clarify the text.

THE DESIGN OF OPERATIONAL AMPLIFIER CIRCUITS, WITH EXPERIMENTS, by Howard M. Berlin. E&L Instruments, Inc., 61 First St., Derby, CT 06418. 266 pp. 6 × 9 in. Softcover $8.50.

The beginning experimenter and hobbyist will find this latest in the *Bugbook* series useful in a home study program dealing with the design and operation of different types of op-amp circuits. Each chapter contains its own set of experiments on a wide spectrum of circuits, from linear amplifiers to single-supply units. Chapter 1 introduces the reader to the basics; other chapters deal with the fundamental circuits using bipolar and Norton-type op-amps; and Chapter 10 discusses the instrumentation amplifier used in augmenting low-level signals.

WORKSHOP IN SOLID STATE, Second Edition, by Harold E. Ennes. Howard W. Sams & Co., Inc., 4300 W. 62nd St., Indianapolis, IN 46268. 384 pp. 5½ × 8½ in. Softcover $7.95.

The student and technician with previous training in electronics will find this book helpful in making the transition from vacuum-tube circuitry to solid-state devices. The material was originally developed to aid in training broadcast technicians, but the basic principles apply to other branches of electronics as well.

The text covers the fundamentals of solid-state devices, circuits for both linear and pulse applications, logic-circuit principles and testing and servicing information. Test questions follow most chapters, with answers in an appendix in the back of the book.

HOME-BREW HF/VHF ANTENNA HANDBOOK, by William Hood. TAB Books, Blue Ridge Summit, PA 17214. 210 pp. 5 × 8¼ in. Softcover, $5.95; hardcover, $8.95.

This how-to guide on building antennas contains complete down-to-earth instructions on designing, constructing, installing, selecting, buying and customizing any HF/VHF antenna, from a basic dipole to stacked-beam arrays. The first two chapters deal with essential antenna principles, formulas, systems and configurations. Also included are in-depth examinations of wave propagation, radiation characteristics, transmission lines, baluns, etc., plus instructions and schematics for constructing dummy antennas, SWR meters, impedance bridges, L- and Pi-networks, and many more. Contains four appendixes and an index. **R-E**

next month

JANUARY 1979

- **Build An Audio Test Station**
- **How To Troubleshoot Communication Receivers**
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PLUS

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Build A Compact 600 MHz Freq Counter

CET Test

Computer Corner

HOBBY COMPUTER POWER SUPPLIES
Continued from page 59

Keep it cool

While giant strides have been made in the miniaturization of electronic components, nobody has yet miniaturized the *joule* (i.e., watt-second). Heat causes many electrical component failures, and it is likely that series-pass transistors and regulators will fail if allowed to get too hot. Additionally, most such devices have a temperature coefficient that defines an output voltage change in percent-per-degree centigrade (%/°C).

At current levels up to about 5 amperes, ordinary heat-sinking and convection cooling will usually suffice, but at higher current levels it becomes increasingly necessary to use a blower or fan in addition to the heat sink.

In one configuration of my Z-80 system, I used a heat-sinked HEP S7000 in the circuit of Fig. 3 to provide 5 volts at 10 amperes. The heat sink was one of the large finned International Rectifier models sold in hobbyist outlets. This transistor got so hot after 20 minutes of operation at near full load that a first degree burn would reward anyone foolish enough to touch it! But a 50-cfm "whisper" fan reduced the temperature to the "barely hot" level in only a few minutes!

In short, it is good practice to always use forced-air cooling on power regulators and series-pass transistors operated at more than a few amperes of constant load current. Keeping the case temperature low will not only improve longevity, but will also prevent output voltage drift due to thermal changes. The rules for keeping a regulator and rectifier cool are:

1. Mount the IC regulator, series-pass element and rectifiers on heat sinks, not just on the chassis.
2. Use silicone/heat-transfer grease between all devices and their respective heat sinks.
3. Blow 40 to 105 cubic-feet-per-minute (cfm) of air across the heat-sink fins. Such fans or blowers can usually be obtained at low-cost surplus or somewhat higher cost at retail. The investment is well worth it—remember that bit about the silicon-to-carbon converter! **R-E**

SPEAKER CABLES

continued from page 93

in the opposite direction. Both conductor layers are wound at a 45-degree angle, constantly crisscrossing each other.

The *High Definition* cable manufactured by Audio-Source (see Fig. 7) is the least expensive, costing 80 cents-per-foot, with a characteristic 10-ohm impedance; having 10 pairs of braided wire; and connected in parallel to reduce DC resistance and with specially finished tips.

It is impossible to predict accurately how certain speaker/wire/amplifier combinations will perform. Some amplifiers cannot handle capacitances greater than 6000 pF and shut down. Some amplifiers cannot *handle too little capacitance*, and shut down or produce a metallic or ringing sound. Dr. Maier, president of the Disc Washer Group, distributors of *Smog Lifters*, says: "Very fine amplifiers with highly balanced output stages, with complementary power supplies will sustain up to one microfarad just like certain amps will play 'into' and sound good on electrostatic speakers. Amps, which do not like electrostatic speakers, and which sound terrible on them, tend to be candidates for super cable problems."

Some high-powered amplifiers have had problems with too small a capacitance—1500 and 15,000 pF. Engineers say this can be avoided by inserting an inductor in the output circuit.

The *Smog Lifter* cables are claimed to have a lower capacitance (480 pF) than other super cables. Dr. Maier believes "the capacitance of the *Smog Lifters* allows most amps to be used, but we are including a disclaimer of consequential damage with our words of caution for the protection of everybody."

The problem is somewhat similar to using penicillin or any other drug—not all people respond the same way. There is a dynamic equation between speaker wire and amplifier. So here's a word of caution for any potential user: Not all people will hear the difference between a No. 16 wire and a No. 22 wire; nor may they hear the difference between the super cables and the best of conventional cord. You may discover that upgrading your cable doesn't actually make a difference. In my tests, which were not highly controlled blind listening tests, I discovered there was a difference—a cleaner percussive sounds and a tighter bass.

If you're looking for better sound from your audio system, try the super cables (or even just heavier wire) on a money-back basis; you may be pleasantly surprised with the results. **R-E**

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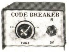

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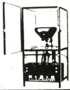

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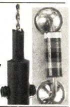

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ELECTRONIC EQUIPMENT HOTLINE is a classified advertising newsletter for professional, industrial, and surplus electronic equipment. Subscriptions $6/year, ads 50¢/word. **PO Box 4768,** Dept RE, Panorama City, CA 91412

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2SA 234	.45	.53	.59
2SA 473	.45	.53	.59
2SA 484	1.50	1.75	1.95
2SA 495	.30	.35	.40
2SA 497	1.00	1.20	1.30
2SA 509	.30	.35	.40
2SA 561	.30	.35	.40
2SA 562	.30	.35	.40
2SA 564A	.20	.27	.30
2SA 634	.40	.45	.50
2SA 643	.30	.40	.45
2SA 673	.35	.40	.45
2SA 678	.35	.40	.45
2SA 682	.80	.90	1.00
2SA 683	.30	.35	.40
2SA 684	.35	.40	.45
2SA 695	.40	.53	.59
2SA 699A	.50	.64	.70
2SA 706	.85	1.00	1.10
2SA 719	.30	.35	.40
2SA 720	.30	.35	.40
2SA 733	.20	.27	.30
2SA 747	4.20	4.40	4.90
2SA 818	.70	.80	.90
2SA 841	.20	.27	.30

2SB

TYPE	25-UP	10-24	1-9
2SB 22	.30	.35	.40
2SB 54	.20	.27	.30
2SB 75	.35	.40	.45
2SB 175	.20	.27	.30
2SB 186	.20	.27	.30
2SB 324	.30	.35	.40
2SB 337	.70	.80	.90
2SB 405	.30	.35	.40
2SB 407	.80	.90	1.00
2SB 434	.80	.90	1.00
2SB 435	.90	1.10	1.20
2SB 463	.90	1.10	1.20
2SB 473	.80	.90	1.00
2SB 474	.70	.80	.90
2SB 492	.60	.70	.80
2SB 507	.80	.90	1.00
2SB 528D	.70	.80	.90
2SB 595	1.10	1.40	1.50
2SB 596	1.10	1.40	1.50

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2SC 281	.30	.35	.40
2SC 372	.20	.27	.30
2SC 373	.20	.27	.30
2SC 380	.20	.27	.30
2SC 394	.20	.27	.30
2SC 458	.20	.27	.30
2SC 495	.45	.55	.60
2SC 509	.35	.40	.45
2SC 515A	.80	.90	1.00
2SC 517	2.50	2.70	3.00
2SC 535	.30	.35	.40
2SC 634A	.35	.40	.45
2SC 696	1.00	1.20	1.30
2SC 710	.20	.27	.30
2SC 711	.20	.27	.30
2SC 730	3.00	3.20	3.40
2SC 732	.20	.27	.30
2SC 735	.20	.27	.30
2SC 756	1.50	1.80	2.00
2SC 756A	1.50	1.80	2.00
2SC 781	1.90	2.10	2.40
2SC 784	.30	.35	.40
2SC 799	2.00	2.20	2.50
2SC 828	.20	.27	.30
2SC 839	.30	.35	.40
2SC 867	3.20	3.40	3.70
2SC 867A	3.20	3.40	3.70
2SC 897	2.00	2.20	2.50
2SC 930	.20	.27	.30
2SC 945	.20	.27	.30
2SC 983	.50	.64	.70
2SC 959	1.10	1.20	1.30
2SC 1000BL	.35	.40	.45
2SC 1014	.50	.64	.70
2SC 1018	.60	.70	.80
2SC 1030C	1.80	2.10	2.40
2SC 1061	.70	.80	.90
2SC 1079	3.40	3.55	3.90
2SC 1096	.45	.55	.60
2SC 1098	.50	.64	.70
2SC 1111	2.10	2.50	2.80
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2SC 1173	.50	.55	.60
2SC 1226	.50	.55	.60
2SC 1226A	.50	.55	.60
2SC 1239	2.20	2.70	2.90
2SC 1306	1.30	1.45	1.60
2SC 1307	1.90	2.10	2.40
2SC 1318	.35	.40	.45
2SC 1383	.30	.35	.40
2SC 1384	.35	.40	.45
2SC 1419	.60	.70	.80
2SC 1675	.20	.27	.30
2SC 1678	1.10	1.25	1.40
2SC 1728	.70	.80	.90
2SC 1730	.45	.53	.59
2SC 1760	.70	.80	.90
2SC 1816	1.50	1.75	1.95
2SC 1856	.50	.64	.70
2SC 1908	.30	.35	.40
2SC 1909	1.80	2.00	2.25
2SC 1945	4.50	5.00	5.60
2SC 1957	.60	.70	.80
2SC 1970	2.10	2.50	2.80
2SC 1978	5.40	6.00	6.60
2SC 2028	.50	.64	.70
2SC 2029	1.50	1.80	2.00
2SC 2076	.50	.64	.70
2SC 2091	.90	1.10	1.20
2SC 2092	1.80	2.00	2.25
2SC 2166	1.40	1.60	1.80

2SD

TYPE	25-UP	10-24	1-9
2SD 72	.50	.64	.70
2SD 234	.60	.70	.80
2SD 235	.60	.70	.80
2SD 261	.35	.40	.45
2SD 287	2.50	2.70	2.90
2SD 313	.60	.70	.80
2SD 315	.60	.70	.80
2SD 325	.60	.70	.80
2SD 427	1.80	2.00	2.25
2SD 525	.90	1.10	1.20
2SD 526	.60	.70	.80

FET

TYPE	25-UP	10-24	1-9
2SK 19BL	.45	.55	.60
2SK 23	.70	.80	.90
2SK 30	.40	.45	.50
2SK 33	.60	.70	.80
2SK 55	.60	.70	.80
3SK 22Y	1.40	1.60	1.80
3SK 39	.90	1.10	1.20
3SK 40	.90	1.10	1.20
3SK 41	1.30	1.45	1.60
3SK 45	1.30	1.45	1.60
3SK 48	3.40	3.55	3.90
3SK 49	1.30	1.45	1.60

IC

TYPE	25-UP	10-24	1-9
AN 214Q	1.30	1.70	1.90
AN 239	4.20	4.40	4.90
AN 247	2.50	2.70	3.00
AN 274	1.50	1.75	1.95
AN 313	3.00	3.20	3.40
AN 315	1.80	2.00	2.25
BA 511A	1.80	2.00	2.25
BA 521	1.90	2.10	2.40
HA 1151	1.50	1.75	1.95
HA 1156	1.60	1.80	2.00
HA 1306W	2.00	2.20	2.50
HA 1322	2.50	2.70	3.00
HA 1339	2.50	2.70	3.00
HA 1339A	2.50	2.70	3.00
HA 1366	2.50	2.70	2.90
HA 1366W	2.50	2.70	2.90
HA 1366WR	2.50	2.70	2.90
LA 4031P	1.80	2.00	2.25
LA 4032P	1.80	2.00	2.25
LA 4400	1.90	2.10	2.40
LA 4400Y	2.00	2.20	2.50
LA 4420	2.00	2.20	2.50
M51513L	2.00	2.20	2.50
STK 011	3.80	4.00	4.40
STK 013	7.60	8.00	8.80
STK 015	4.20	4.40	4.90
STK 435	4.50	5.00	5.60
TA 7045M	2.00	2.20	2.50
TA 7060P	.70	.80	.90
TA 7061P	.90	1.10	1.20
TA 7062P	1.10	1.25	1.40
TA 7089P	2.00	2.20	2.50
TA 7202P	2.50	2.70	2.90
TA 7203P	2.50	2.70	2.90
TA 7204P	2.00	2.20	2.50
TA 7205P	1.60	1.80	2.00
TA 7310P	1.30	1.45	1.60
TBA 810SH	1.90	2.10	2.40
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TC 5082P	3.40	3.55	3.90
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UHIC 005	4.20	4.40	4.90
UPC 20C	2.10	2.50	2.80
UPC 563	1.90	2.10	2.40
UPC 575C2	1.30	1.45	1.60
UPC 576	1.90	2.10	2.40
UPC 592HZ	.70	.80	.90
UPC 1001	1.90	2.10	2.40
UPC 1008C	4.20	4.40	4.90
UPC 1020H	1.90	2.10	2.40
UPC 1025H	1.90	2.10	2.40
UPC 1154	2.00	2.20	2.50
UPC 1155	2.00	2.20	2.50
UPC 1156	1.90	2.10	2.40
UPC 14305	3.00	3.20	3.40
UPD 861	8.00	8.40	9.50
UPD 857	8.00	8.40	9.50
UPD 858	6.00	6.30	7.00
PLL 01A	3.00	4.20	4.60
PLL 02A	5.00	5.30	5.90
PLL 03A	7.60	8.00	8.80

DIODES

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1S 332	.35	.40	.45
1S 953	.16	.18	.20
1S 1007	.35	.40	.45
1S 1209	.35	.40	.45
1S 1211	.35	.40	.45
1S 1555	.20	.22	.25
1S 1588	.20	.22	.25
1S 1885	.16	.18	.20
1S 2076	.20	.22	.25
1S 2093	.35	.40	.45
1S 2473	.16	.18	.20
1N 34	.12	.13	.15
1N 60	.12	.13	.15
10D 1	.30	.35	.40
10D 10	.45	.55	.60
V06B	.30	.35	.40

ZENERS

TYPE	25-UP	10-24	1-9
WZ 071	.20	.22	.25
WZ 075	.20	.22	.25
WZ 090	.20	.22	.25
WZ 120	.20	.22	.25
WZ 192	.20	.22	.25

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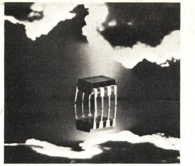

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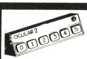

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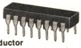

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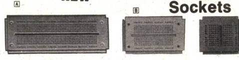

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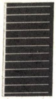

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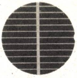

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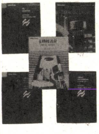

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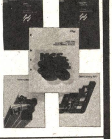

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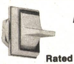

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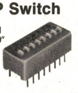

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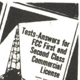

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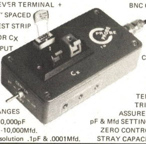

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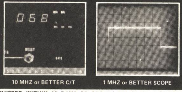

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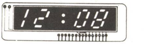

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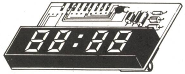

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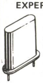

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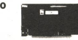

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20 Pin W/W	.90	20 Pin S/T	.34
22 Pin W/W	.93	22 Pin S/T	.35
24 Pin W/W	.85	24 Pin S/T	.41
28 Pin W/W	1.15	28 Pin S/T	.49
40 Pin W/W	1.49	40 Pin S/T	.63

CONNECTORS

6 Pin Single S/E	1.49
15/30 Dual S/E	1.95
18/36 Dual S/E	2.35
22/44 Dual S/E	2.95
40/80 W/W	4.95
43/86 Dual W/W/S/T	6.50
50/100 IMSAI W/W	4.75
50/100 IMSAI S/T	4.75
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DB25P	3.25
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CTS206-4	$1.75	CTS208-8	$1.95
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LIVERMORE BASIC
ON 65K ROM
THAT'S RIGHT ON ROM!!!
OUR PRICE only ... $95.00

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13 Slot MotherBoard (WMC)	32.95
9 Slot MotherBoard (WMC)	29.95
8 Slot Mother (expandable)	34.95

ATTENTION KIM USERS

KIMSAI-expansion to S-100	125.00 Kit/165.00
KIMSI to KIM Connector	5.75/pair
KIM 1 6502 Single Board Computer	245.00
KIM 1 Power Supply	59.95
KIM Memory Plus - (consists of 8K Ram, 8K 2716 Eprom, Programmer, I/O etc.)	245.00
KIM SOFTWARE	
• Please package (cassette) 12 games	16.95
• Help Editor package (cassette)	16.95
• Help Mailing List pkg. (cassette)	16.95
• Help Info Retrival pkg. (cassette)	16.95
• Microchess (cassette)	16.95
• Microaid Assembly/Disassem/Editor	27.95
• Microaid Source Listing (cassette)	27.95
• Tiny Basic for KIM (paper tape)	10.95

ATTENTION PET USERS

BETSI-pet expansion to S-100	105.00 Kit/160.00
PET Connector Kit. Includes (4) Connectors for memory expansion, IEEE 488 I/O, cassette I/O and parallel user port	7.95 /set
Video Buffer (converts to Std. Video)	29.95
Petunia (Music Board)	29.95
Combo (Video & Petunia)	49.95
Beeper (signals tape load)	24.95

ATTENTION TRS-80 USERS
Now in stock the hard to find 20/40 Memory Expansion Connector with contacts ... 7.95

ATTENTION APPLE II USERS

Apple II w/16K	$1045.00
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Floppy Disk II w/Interface	595.00
Floppy Disk II	495.00
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Parallel I/O Card	180.00
Communications I/O Card	180.00
PR40 Printer I/O w/cassette	49.95
2716 Eprom Burner w/adapt	99.95
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STATIC RAM HEADQUARTERS

	1-24	25-99	100
21L02 450ns.	1.30	1.25	1.15
21L02 250ns.	1.59	1.55	1.45
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211-1	3.75	3.65	3.55
2112-1	2.95	2.85	2.65
2101-1	2.90	2.70	2.55
2114-3 300ns.	9.95	9.75	8.25
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TMS4044	8.95	8.75	7.00
TMS4045	8.95	8.75	7.00
EMM4200A	11.50	9.95	8.95
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CHARGE COUPLED DEVICES
16K CCD - First time offered Fairchild 460 CCD 16K Memory (now you can experiment with CCD technology at a reasonable price. 17 page Application note supplied with each order. Quantity limited)
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Microprocessor Timebases TV Game

Frequency	Price	Frequency	Price
1.0MHz	$5.85	6.0MHz	$ 4.95
1.8432	4.95	6.144	4.95
2.0MHz	5.85	6.5536	4.95
2.01MHz	2.95	10.0MHz	4.95
2.097152MHz	5.85	13.0MHz	4.95
2.4576MHz	5.85	14.31818	4.95
3.579545MHz	1.50	18.0MHz	4.95
4.0MHz	4.95	18.432MHz	5.95
4.194304MHz	5.95	20.0MHz	4.95
4.91520MHz	5.95	22.1184MHz	5.95
5.0MHz	4.95	27.0MHz	5.95
5.0688	4.95	36.0MHz	5.95
5.7143MHz	5.95	48.0MHz	5.95
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DISPLAYS/OPTO

DL 704/707/CC/CA .300	1.25
FND359 CC .357	.95
FND 500/507/CC/CA .500	1.35
FND 503/510 CC/CA .500	.95
FND 800/807 CC/CA .800	2.50
Bowmar 9 digit bubble	.99
FSC 8024 4 digit CC .800	4.95
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NEW 1978 CATALOGUE SEND 25¢ POSTAGE

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	Discount Cash	Computer Credit Card
Apple II/16K	$1045.00	$1065.00
Compucolor II	Contact sales desk	
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ADM 3 Assem.	829.95	865.00
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AM100	Contact sales desk	
Imsai w/22 slots	599.00	617.00
Oliver 2708/16 Programr	275.00	288.00
Houston Digital Plotter	999.00	999.00
Pennywhistle Modem	129.95	129.95
Cromemco 16K Ram	449.00	462.00
Hazeltine 1500	1175.00	1195.00
Okidata 110 w/TF RS232	1675.00	1705.00
Okidata 22 w/TF RS232	2705.00	2810.00
MEK 6800 D2 Kit	235.00	Same
KIM I 6502	229.95	Same
Intercept Jr 6100	281.00	Same
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FIRST QUALITY CARBON RESISTOR KITS 1/4W

Each kit contains all the EIA designated 10% values from 2.2 ohms to 8.2 megohms. Your cost: Only $.02 per resistor.

KIT A
1,000 Pcs. 19.95 ppd.
Includes FREE 9-drawer box ($5.00 value)

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500 Pcs. 9.95 ppd.
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250 Pcs. 4.95 ppd.
in Poly Bag

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Aluminum Electrolytic, Tantalum and Ceramic Capacitor Kits. Semiconductor Kits, too. Lamps also.

We have **over 2,000 quality Receiving Tubes.** Many hard-to-get types. **All at 75% off list.**

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MULTI-TESTER

IT TESTS TRANSISTORS AND LED's AS WELL!!

YX-360TR

TRANSISTOR TESTER
20K OHMS/VOLT

SPECIFICATIONS

DCV	0-0.1-0.5-2.5-10-50-250-1000 (20kΩ/V) ±3%, 25k (w/HV probe)
DCA	0-50μA 0-2.5-25mA 0-0.25A (100mV & 250mV) ±3%
ACV	0-10-50-250-1000 (8kΩ/V) ±4% Freq. 30Hz to 30kHz
Ω	×1 ×10 ×1k ×10k (max. 20M) Batt. 1.5V×2 & 9V×1
dB	−10 to +62
ICEO	0-150μA 0-15-150mA ±5%
hFE	0-1000 ±3% (w/connector)

150×100×57 420gr

$28.50

SANYO HYBRID

Audio power amplifiers I.C. Max. hi-fi output power, minimum ext. components needed.

15 Watts	STK- 28	$ 8.50
23 Watts	STK-054	$13.50
30 Watts	STK-056	$17.50
50 Watts	STK-050	$26.50
10W + 10W (stereo)	STK-040	$14.50
15W + 15W (stereo)	STK-041	$25.50
20W + 20W (stereo)	STK-043	$31.50

*data sheet comes with purchase

THE MOST POPULAR MM5314 CLOCK KIT

Features:
* 12/24 Hours Display
* 50/60 Hz Input
* 6 Digits Bright Orange Readouts

Kit includes plastic case, MM 5314 I.C. One set transistor drivers, P.C. Board, gas discharge displays, all other electronic parts and transformer. Catalog no. DC-8SP

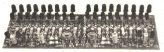
SPECIAL PRICE, $16.95 PER KIT

COMPUTER GRADE CAPACITORS

All capacitors are Brand New U.S. made in standard size

9000MFD	50V	$3.25 EA.
11000MFD	35V	$3.20 EA.
14500MFD	40V	$3.40 EA.
23000MFD	20V	$3.00 EA.
58000MFD	20V	$3.20 EA.
100,000MFD	6V	$2.50 EA.

9 STEPS LED LEVEL INDICATOR KIT



for most stereo amplifiers
This new project works as a pair of VU meter to indicate the output level of your amplifier from -20dB to +3dB. Kit includes all LED, transistors, electronic components, P.C. Board and instructions.
Easy to build and fun to see.
ONLY $12.50 EA.

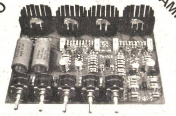
ULTRA-SONIC REMOTE CONTROL SWITCH KIT

NEW

Kit includes the transmitter, the receiver, ultra sonic transducers, P.L.L. I.C., all other electronic parts and P.C. Boards. Ideal for control TV, light, fan or garage door. Case not included.

$18.50 PER KIT

STEREO 60W + 60W AMPLIFIER



COMPLETED UNIT—NOT A KIT!

OCL pre amp. & power stereo amp. with bass, middle, treble 3-way tone control. Fully assembled and tested, ready to work. Total harmonic distortion less than 0.5% at full power. Output maximum is 60 watts per channel at 8Ω. Power supply is 24 - 36V AC or DC. Complete unit only **$49.50 ea.**
Power transformer **$ 8.50 ea.**

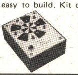
DIP SWITCHES

(On-Off Contacts)

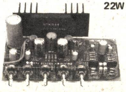
4 positions	$1.50
5 positons	$1.60
6 positions	$1.70
7 positions	$1.70
8 positions	$1.80
10 positions	$2.00

ELECTRONIC WHEEL OF FORTUNE KIT!

With 10 numbers split into black and white on dial. The LED turns when you hit the play switch, then it slows down and stops on one number. It sounds like a motor inside, but there is none. Lots of fun and easy to build. Kit comes with nice looking case, all electronic parts, P.C. Board and LEDs. Battery not included. **$12.50**



22W + 22W STEREO HYBRID AMPLIFIER KIT



It Works in 12V D.C. As Well! Kit includes 1 PC SANYO STK-024 stereo power amp. IC LM 1458 as pre amp, all other electronic parts, PC Board, all control pots and special heat sink for hybrid. Power transformer not included. It produces ultra hi-fi output up to 44 watts (22 watts per channel) yet gives out less than 0.1% total harmonic distortion between 100Mz and 10KHz. **$32.50 PER KIT**

POWER TRANSFORMER $6.50 EACH

SUPER 15 WATT AUDIO AMP KIT

Uses STK-015 Hybrid Power Amp

Kit includes: STK-015 Hybrid IC, power supply with power transformer, front Amp with tone control, all electronic parts as well as PC Board. Less than 0.5% harmonic distortion at full power ½dB response from 20—100,000 Hz. This amplifier has QUASI—Complimentary class B output. Output max is watt (10 watt RMS) at 4Ω.

ONLY $23.50 each

FM WIRELESS MIC KIT

This new model FM wireless MIC kit uses 3 high freq. transistors, works in the FM range (88-108 MHz). It transmits the sound wave fidelity clearly over long distances (up to 250 ft.). Kit comes with all electronic parts, P.C. Board and mini microphone!

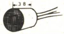
$6.95 EACH KIT

WE FOUND THE CASE FOR THE FM MIC!!

Small nice looking aluminum case size like a pack of cigarettes. It is an intercom. Audio amp inside with a mic jack, a mini toggle sw on top, can be used for many projects. We give you the circuit data as well.

VERY SPECIAL PRICE 2 for $4.99

Sub-Mini Size Condenser Microphone
$2.50 each
FET Transistor Built-in



63 KEYS ASC11 DECORDED COMPLETE KEYBOARD
by Honeywell
with dual color key tops, uses TMS 5000 decorder LSI. (schematic data included)

SPECIAL
$56.50
NOT A KIT!

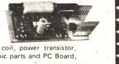
PROFESSIONAL CASE

for our 0-30V Power Supply. It is a nice looking metal cast case with giant 4" volt/amp meter; output blinding post and fuse holder, on/off switch and line cord! **ONLY $21.50 EA.**

CASE 030

FLUORESCENT LIGHT DRIVER KIT

12V DC POWERED
Lights up 8～15 Watt Fluorescent Light Tubes
Ideal for camper, outdoor Auto or Boat



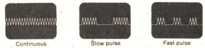
Kit includes high voltage coil, power transistor, heat sink, all other electronic parts and PC Board, light tube not included!

ONLY $5.50 PER KIT

MANY SOUND DECISIONS!

Solid state sound indicator operating voltage 6V DC 30μA. Small size approximately ¾" X 1¼".
Model EB2116 (Continuous)
Model EB2126 (Slow Pulse)
Model EB2136 (Fast Pulse)

$3.60 EACH



Continuous　Slow pulse　Fast pulse

POWER SUPPLY KIT

0-30V D.C. REGULATED

Uses UA723 and ZN3055 Power TR output can be adjusted from 0-30V, 2 AMP. Complete with PC board and all electronic parts.

0-30 POWER SUPPLY **$10.50 each**

Transformer for Power Supply, 2 AMP 24V x 2 $6.50
30V DC Panel Meter $4.20

12V DC MINI RELAY
P.C. Board Solder Type

2AMP Contact SPDT $1.30 EA
2AMP Contact DPDT $1.75 EA
5AMP Contact 4PDT $2.20 EA

12V D.C. AUTO DIGITAL CLOCK
Complete Unit
Not a Kit!

0.4" blue color 4 digits display. Turn off readouts when car is not running. X'tal controlled time base for time accuracy. Special designed case for easy mounting on top of your dashboard. Ideal for car, boat and campers.

SALE! ONLY ~~$28.50~~ ea. **$24.50**

HEAVY DUTY CLIP LEADS

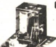
10 pairs — 5 colors
Alligator clips on a 22" long lead. Ideal for any testing.

$1.85/pack

1Watt AUDIO AMP

All parts are pre assembled on a mini PC Board
Supply Voltage 6～9V D.C.
SPECIAL PRICE $1.95 ea.

ELECTRONIC SWITCH KIT



CONDENSER TYPE
Touch On Touch Off uses 7473 I.C. and 12V relay
$5.50 each

"FISHER" 30 WATT STEREO AMP
MAIN AMP (15W X 2)

Kit includes 2 pcs. Fisher PA 301 Hybrid IC all electronic parts with PC Board. Power supply ± 16V DC (not included). Power band with (KF 1% ± 3dB). Voltage gain 33dB. 20Hz — 20KHz.

Super Buy Only $18.50

AA SIZE NI-CD BATTERY
6 in a pack (1.2V X 6) 500 MA/HR
$4.80 PER PACK

MINI-SIZED I.C. AM RADIO

Size smaller than a box of matches!
Receives all AM stations
Batteries and ear phone included

Only $8.50

AUTO ALARM KIT

The Crimefighter Auto Alarm is an electronic, self-controlled auto protection system, normally mounted within the glove box of an automobile. Two minutes after turning off the ignition, the alarm automatically turns itself "on". When auto is re-entered, the horn will sound after a 10-45 second entry delay. The automobile owner, by inserting the ignition key, will activate the alarm. Once activated, the alarm will sound for two minutes before automatically turning off. The alarm then resets and is ready to again protect the vehicle from unwanted entry.

FEATURES: Simple installation: 5 wires, Automatically turns on when auto is parked, Adjustable entry time, Extended exit time to allow for unrushed exit from vehicle, Numerous applications include protection of boats, campers, trailers, motorcycles, trucks, Cannot be deactivated by "hot wiring" an auto, Cannot be turned off without ignition key, Negative ground only.

ONLY $14.00 PER KIT

BRAND NEW
EVEREADY CH15 AA size NI-CD 500 MA/HR. **4 for $5.50**
Only limited quantity available

5W AUDIO AMP KIT

2 LM 380 with Volume Control
Power Supply 6～18V DC
only $5.00 ea.

Sub Mini Size PANEL METER
500 UA
ONLY $1.20 ea

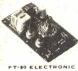
MINI-MINI TOGGLE SWITCH

Half size of subminl toggle switch rated 3 amp 125V AC contact

		1-9	10-99
MS 244	SPDT	1.00	0.90
MS 245	DPDT	1.20	1.10

LARGE QUANTITY AVAILABLE FOR OEM

TIMER KIT



Time Controlled from 1-100sec.
Ideal to be used as timer delay unit for burglar alarm, photo service, and other purposes.
Max. loading 110V, 2 AMP.
Supply voltage 12-18V DC.

FT-80 ELECTRONIC IC TIMER **$11.50 each**

PANEL METER (D.C. Type)
Size 60MM X 66MM
White Face Type

$5.50 ea.

0-50 UA	0-30V
0-1MA	0-50V
0-5MA	0-100V
0-100MA	

ELECTRONIC ALARM SIREN

COMPLETE UNIT
Ideal for use as an Alarm Unit or hookup to your car back up to make a reverse indicator.
Light Output up to 130dB
Voltage Supply 6～12V **$7.50**

AU—999

4 DIGITS ALARM CLOCK

COMPLETE UNIT NOT A KIT

- 0.5" RED LED READ OUT
- 24 HRS. ALARM SET
- 10 MINS. SNOOZE SET
- AM/PM ALARM INDICATORS
- SECOND DISPLAY SWITCH
- AUTOMATIC BRIGHTNESS CONTROL
- COMPACT AND HANDSOME PACKING
- 110V AC 60HZ INPUT

$17.50 EACH

TRANSFORMERS

ALL 117 VOLT INPUT

30V	4AMP	$7.50 EA.
36V CT	3AMP	$6.50 EA.
48V CT	3AMP	$6.50 EA.
24V CT	3AMP	$6.50 EA.
24V CT	0.8AMP	$1.80 EA.
12V CT	0.8AMP	$1.80 EA.
12V CT	120MA	$1.25 EA.

AC POWER SUPPLY

Wall Type Transformer

12V AC	Output	200MA	$2.75 EA.
16V CT AC	Output	100MA	$2.10 EA.
6V DC	Output	120MA	$1.90 EA.
12V DC	Output	100MA	$1.90 EA.

SUBMINIATURES TOGGLE SWITCHES

SPDT	OnOff	$1.30 ea
DPDT	OnOff	$1.50 ea
3PDT	OnOff	$1.75 ea

Mini size Rocker Type
Also available at the same price

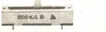
SOUND ACTIVATED SWITCH

All parts completed on a PC Board
SCR will turn on relay, buzzer or trigger other circuit for 2～10 sec. (adjustable)
Ideal for use as door alarm, sound controlled toys and many other projects
Supply voltage 4.5V～9V D.C.
$1.75 ea./2 for $3.00

MINI SIZE REED RELAY

Approx. 1" square
SPST Normal Open
Contact rated 1AMP
Coil 6～12V DC
All brand new by AMF
3 for $2.00

LINEAR SLIDE POT 500KΩ SINGLE
Metal Case 3" Long
2 FOR $1.20



2¼" ROUND SPEAKER

8Ω 0.25W
for most sound projects

SPECIAL 3 for $2.00

WIDE ANGLE PANEL METER

1¾" x ¾"
IMA Full Scale
(scale marks 0-100)
$1.50 each

PUSH-BUTTON SWITCH

N/Open Contact
Color: Red, White, Blue, Green, Black. **4/$1.00**
N/Close also Available **50¢ ea.**
LARGE QTY. AVAILABLE

DIGITAL ELECTRONIC LOCK KIT

for auto ignition, entry door, burglar alarm, etc.
$6.50 ea. 4 Digits Programmable to Any Combination
CMOS I.C. IN CIRCUIT
400Ω RELAY AND KEY PAD NOT INCLUDED

HOUR INDICATOR

This unit is 1 5/8" long operating voltage 4V D.C. will tell you how many hours your circuit or machine has been in service up to 100 hours.

Limited Quantity ONLY $1.75 ea.

SOLID STATE ELECTRONIC BUZZER

Mini size 1" x ¾" x ¾"
Supply voltage 1.5V 12V
Ideal for Alarm or Tone Indicator
$1.50 each

I.C. TEST CLIPS

Same as the E-Z clips
With 20" Long Leads
In Black and Red Colors
$2.75 per pair

BATTERY POWERED FLUORESCENT LANTERN

FEATURES

- Circuitry: designed for operation by high efficient, high power silicon transistor which enable illumination maintain in a standard level even the battery supply drops to a certain low voltage.
- 9" 6W cool/daylight miniature flourescent tube.
- 6 X 1.5V UM-1 (size D) dry cell battery.
- Easy sliding door for changing batteries.
- Stainless reflector with wide angle increasing lumination of the lantern.

$9.60 EACH
MODEL 888-R

MINIMUM ORDER $10.00. California residents add 6% sales tax and 10% shipping.
Out of state add 15% of total purchase for shipping charges, out of USA and Overseas add 25% of total purchase. 12/78
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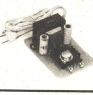
Jameco ELECTRONICS New Kits

a division of JAMES ELECTRONICS of California

Regulated Power Supply



- Uses LM 309K
- Heat sink provided
- P.C. board construction
- Provides a solid 1 amp @ 5V
- Includes components, hardware and instructions
- Sizes: 3-1/2" x 5" x 2" high

JE200 $14.95

Function Generator Kit

- Provides 3 basic wave-forms: sine, triangle & square wave
- Frequency range from 1 Hz to 100K Hz
- Output amplitude from 0-volts to over 6 volts (peak to peak)
- Uses a 12V supply or a ± 6V split supply
- Includes chip, P.C. board, components and instructions.

JE2206B $19.95

Digital Stopwatch Kit

- Use Intersil 7205 Chip
- Plated thru double-sided P.C. Board
- LED display (red)
- Times to 59 min. 59.59 sec. with auto reset
- Quartz crystal controlled
- Three stopwatches in one: single event, split (cummulative) and taylor (sequential timing)
- Uses 3 penlite batteries
- Size: 4.5" x 2.15" x .90"

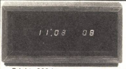
JE900 $39.95

4-Digit Clock Kit

- Bright .357" ht. red display
- Sequential flashing colon
- 12 or 24 hour operation
- Extruded aluminum case (black)
- Pressure switches for hours, minutes and hold modes
- Includes all components, case and wall transformer
- Size: 3-1/4" x 1-3/4" x 1-1/4"

JE730 $14.95

6-Digit Clock Kit



- Bright .300 ht. common cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 20 feet
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6-3/4" x 3-1/8" x 1-3/4"

JE701 $19.95

Jumbo 6-Digit Clock Kit

- Four .630" ht. and two .300" ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6-3/4" x 3-1/8" x 1-3/4"

JE747 $29.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES			
8080A	CPU		$ 9.95
8212	8-Bit Input/Output		3.25
8214	Priority Interrupt Control		5.95
8216	Bi-Directional Bus Driver		3.49
8224	Clock Generator/Driver		3.95
8226	Bus Driver		3.49
8228	System.Controller/Bus Driver		5.95
8238	System Controller		5.95
8251	Prog. Comm. 1/0 (USART)		7.95
8253	Prog. Interval Timer		14.95
8255	Prog. Periph. 1/0 (PPI)		9.95
8257	Prog. DMA Control		19.95
8259	Prog. Interrupt Control		19.95
6800/6800 SUPPORT DEVICES			
MC6800	MPU		$14.95
MC6802CP	MPU with Clock and Ram		24.95
MC6810API	128X8 Static Ram		5.95
MC6821	Periph. Inter. Adapt (MC6820)		7.49
MC6828	Priority Interrupt Controller		12.95
MC6830L8	1024X8 Bit ROM (MC68A30-8)		14.95
MC6850	Asynchronous Comm. Adapter		7.95
MC6852	Synchronous Serial Data Adapt.		9.95
MC6860	0-600 bps Digital MODEM		12.95
MC6862	2400 bps Modulator		14.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)		2.25
MICROPROCESSOR CHIPS—MISCELLANEOUS			
Z80(780C)	CPU		$19.95
Z80A(780-1)	CPU		24.95
CDP1802	CPU		19.95
2650	MPU		19.95
8035	8-Bit MPU w/clock, RAM, 1/0 lines		19.95
P8085	CPU		19.95
TMS9900JL	16-Bit MPU w/hardware, multiply & divide		49.95
SHIFT REGISTERS			
MM500H	Dual 25 Bit Dynamic		$.50
MM503H	Dual 50 Bit Dynamic		.50
MM504H	Dual 16 Bit Static		.50
MM506H	Dual 100 Bit Static		.50
MM510H	Dual 64 Bit Accumulator		.50
MM5016H	500/512 Bit Dynamic		.89
2504T	1024 Dynamic		3.95
2518	Hex 32 Bit Static		4.95
2522	Dual 132 Bit Static		2.95
2524	512 Static		.99
2525	1024 Dynamic		2.95
2527	Dual 256 Bit Static		2.95
2528	Dual 250 Static		4.00
2529	Dual 240 Bit Static		4.00
2532	Quad 80 Bit Static		2.95
2533	1024 Static		2.95
3341	Fifo		6.95
74LS670	4X4 Register File (TriState)		1.95
UART'S			
A-Y-5-1013	30K BAUD		5.95
MICROPROCESSOR MANUALS			
M-Z80	User Manual		$7.50
M-CDP1802	User Manual		7.50
M-2650	User Manual		5.00
ROM'S			
2513(2140)	Character Generator(upper case)		$9.95
2513(3021)	Character Generator(lower case)		9.95
2516	Character Generator		10.95
MM5230N	2048-Bit Read Only Memory		1.95
RAM'S			
1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024X4	Static 450ns	9.95
2114L	1024X4	Static 450ns low power	10.95
2114-3	1024X4	Static 300ns	10.95
2114L-3	1024X4	Static 300ns low power	11.95
5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4.95
7489	16X4	Static	1.75
74S200	256X1	Static Tristate	4.95
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16 pin	14.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00
PROM'S			
1702A	2048	FAMOS	$5.95
TMS2516 (2716)	16K*	EPROM(Intel 2716)	49.95
	*Requires single +5V power supply		
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I	16K**	EPROM	29.95
	**Requires 3 voltages, —5V, +5V, +12V		
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

XMAS SPECIAL

The Sinclair PDM35. A personal digital multimeter for only $59.95

Now everyone can afford to own a digital multimeter

A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It's got all the functions and features you want in a digital multimeter, yet they're neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 is supplied completely assembled with test leads and prods, protective wallet and Operator's Manual.

The Sinclair PDM35 is tailor-made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, computer specialists, radio and electronic hobbyists will find it ideal.

Technical specification

DC Volts (4 ranges)
Range: 1 mV to 1000 V.
Accuracy of reading 1.0% ± 1 count.
Note: 10 MΩ input impedance.

AC Volts (40 Hz-5 kHz)
Range: 1 V to 500 V.
Accuracy of reading: 1.0% ± 2 counts.

DC Current (6 ranges)
Range: 1 nA to 200 mA.
Accuracy of reading: 1.0% ± 1 count.
Note: Max. resolution 0.1 nA.

Resistance (5 ranges)
Range: 1Ω to 20 MΩ.
Accuracy of reading: 1.5% ± 1 count.
Also provides 5 junction-test ranges.

Dimensions: 6 in x 3 in x 1½ in.

Weight: 6½ oz.

Power supply: 9 V battery or Sinclair AC adapter. (Battery not incl.)

Sockets: Standard 4 mm for resilient plugs.

Options: AC adapter for 117 V 60 Hz power. De-luxe padded carrying wallet.

XMAS SPECIAL - Get your PDM-35 PLUS the 117 volt AC Adapter and Padded carrying case for only $64.50 (Retail value $73.85)

B+K PRECISION 3½-Digit Portable DMM

- Overload Protected
- .3" high LED Display
- Battery or AC operation
- Auto Zeroing
- 1mv, 1Va, 0.1 ohm resolution
- Overange reading
- 10 meg input impendence
- DC Accuracy 1% typical

Ranges: DC Voltage - 0-1000V
AC Voltage: 0-1000V
Freq. Response: 50-400 HZ
DC/AC Current: 0-100mA
Resistance: 0-10 meg ohm
Size: 6.4" x 4.4" x 2"

Model 2800 $99.95

Comes with test leads, operating manual and spare fuse

Accessories:

AC Adapter BC-28	$9.00
Rechargeable Batteries BP-26	20.00
Carrying Case LC-28	7.50

CSC 100 MHz 8-Digit Counter

CONTINENTAL SPECIALTIES CORPORATION

- 20 Hz-100 MHz Range
- .6" LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75" x 7.38" x 5.63"
- Four power souces, i.e. batteries, 110 or 220V with charger 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95

ACCESSORIES FOR MAX 100:

Mobile Charger Eliminator use power from car battery — **Model 100 — CLA $3.95**

Charger/Eliminator use 110 V AC — **Model 100 — CAI $9.95**

New CSC Mini-Max 6 Digit 50MHz Frequency Counter

CONTINENTAL SPECIALTIES CORPORATION

- Guaranteed frequency range of 100 Hz to 50 MHz
- Full 6 digit display with antiglare window
- Fully automatic-range, polarity, slope, trigger, input level switching not required.
- Lead-zero blanking—All zeros to the left of the first non-zero digit are blanked. Kilo Hertz and Mega Hertz decimal points automatically light up when the unit is turned on.
- Built in input overvoltage protection.
- Use 9V Battery or 110/220V power.
- Complete with mini antenna.
- Lightweight — Only 8oz.

MINI-MAX $89.95

Accessories For Mini-Max

Part No.	Description	Price
MM-A4	Antenna	$ 3.95
MM-C5	Carrying case	5.95
MM-IPC	Input cable with clip leads	3.95
MM-AC2	110V adapter	9.95
MM-AC3	220V adapter	9.95

$5.00 Minimum Order – U.S. Funds Only
California Residents – Add 6% Sales Tax

Spec Sheets — 25¢
1979 Catalog Available—Send 41¢ stamp

NEW 1979 Catalog

Jameco ELECTRONICS
a division of JAMES ELECTRONICS of California

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1021 HOWARD AVENUE, SAN CARLOS, CA 94070
Advertised Prices Good Thru December

The Incredible "Pennywhistle 103"

$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modern and terminal for telephone "hamming" and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method .....Frequency-Shift Keying, full-duplex (half-duplex selectable).
Maximum Data Rate ....300 Baud.
Data Format ....Asynchronous Serial (return to mark level required between each character).
Receive Channel Frequencies ...2025 Hz for space; 2225 Hz for mark.
Transmit Channel Frequencies ..Switch selectable: Low (normal) = 1070 space, 1270 mark; High = 025 space, 2225 mark.
Receive Sensitivity ....−46 dbm accoustically coupled.
Transmit Level ....−15 dbm nominal. Adjustable from −6 dbm to −20 dbm.
Receive Frequency Tolerance ...Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz.
Digital Data Interface ....EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar).
Power Requirements ....120 VAC, single phase, 10 Watts.
Physical ....All components mount on a single 5" by 9" printed circuit board. All components included.

Requires a VOM, Audio Oscillator, Frequencv Counter and/or Oscilloscope to align.

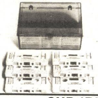
TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K. Kit comes complete with:
* 8 each UPD416 (16K Dynamic Rams)
* Documentation for conversion

TRS-16K $115.00

Special Offer - Order both your TRS-16K and the Sup'R' MOD II Interface kit together (retail value $144.95) **for only $139.95**

COMPUTER CASSETTES



- 6 EACH 15 MINUTE HIGH QUALITY C-15 CASSETTES
- PLASTIC CASE INCLUDED 12 CASSETTE CAPACITY
- ADDITIONAL CASSETTES AVAILABLE #C-15-$2.50 ea

CAS-6 $14.95 (Case and 6 Cassettes)

SUP 'R' MOD II

UHF Channel 33 TV Interface Unit Kit

- Wide Band B/W or Color System
- Converts TV to Video Display for home computers, CCTV camera, Apple II, works with Cromeco Dazzler, SOL-20, IRS-80, Challenger, etc.
- MOD II is pretuned to Channel 33 (UHF).
- Includes coaxial cable and antenna transformer.

MOD II $29.95 Kit

Custom Cables & Jumpers

NEW NEW

DB 25 Series Cables

Part No.	Cable Length	Connectors	Price
DB25P-4-P	4 Ft.	2-DP25P	$15.95 ea.
DB25P-4-S	4 Ft.	1-DP25P/1-25S	$16.95 ea.
DB25S-4-S	4 ft.	2-DP25S	$17.95 ea.

Dip Jumpers

DJ14-1	1 ft.	1-14 Pin	$1.59 ea.
DJ16-1	1 ft.	1-16 Pin	1.79 ea.
DJ24-1	1 ft.	1-24 Pin	2.79 ea.
DJ14-1-14	1 ft.	2-14 Pin	2.79 ea.
DJ16-1-16	1 ft.	2-16 Pin	3.19 ea.
DJ24-1-16	1 ft.	2-24 Pin	4.95 ea.

For Custom Cables & Jumpers, See JAMECO 1979 Catalog for Pricing

CONNECTORS

25 Pin-D Subminiature

DB25P(as pictured)	PLUG	$2.95
DB25S	SOCKET	3.50
DB51226-1	Cable Cover for DB25 P or S	1.75

63-Key Unencoded Keyboard

This is a 63-key, terminal keyboard newly manufactured by a large computer manufacturer. It is unencoded with SPST keys, unattached to any kind of PC board. A very solid molded plastic 13 x 4" base suits most application. IN STOCK **$29.95/each**

Hexadecimal Unencoded Keypad

19-key pad includes 1-10 keys, ABCDEF and 2 optional keys and a shift key. **$10.95/each**

CIRCLE 16 ON FREE INFORMATION CARD

7400 TTL

SN7400N	.16	SN7470N	.29	SN74160N	.89
SN7401N	.18	SN7472N	.29	SN74161N	.89
SN7402N	.18	SN7473N	.35	SN74162N	1.95
SN7403N	.18	SN7474N	.35	SN74163N	.89
SN7404N	.18	SN7475N	.49	SN74164N	.89
SN7405N	.20	SN7476N	.35	SN74165N	.89
SN7406N	.29	SN7479N	5.00	SN74166N	1.25
SN7407N	.29	SN7480N	.50	SN74167N	1.95
SN7408N	.20	SN7482N	.99	SN74170N	1.59
SN7409N	.20	SN7483N	.59	SN74172N	6.00
SN7410N	.18	SN7485N	.79	SN74173N	1.25
SN7411N	.25	SN7486N	.35	SN74174N	.89
SN7412N	.25	SN7489N	1.75	SN74175N	.79
SN7413N	.40	SN7490N	.45	SN74176N	.79
SN7414N	.70	SN7491N	.59	SN74177N	.79
SN7416N	.25	SN7492N	.43	SN74179N	1.95
SN7417N	.25	SN7493N	.43	SN74180N	.79
SN7420N	.20	SN7494N	.65	SN74181N	1.95
SN7421N	.29	SN7495N	.65	SN74182N	.79
SN7422N	.39	SN7496N	.65	SN74184N	1.95
SN7423N	.25	SN7497N	3.00	SN74185N	1.95
SN7425N	.29	SN74100N	.89	SN74186N	9.95
SN7426N	.29	SN74107N	.35	SN74188N	3.95
SN7427N	.25	SN74109N	.59	SN74190N	1.25
SN7429N	.39	SN74116N	1.95	SN74191N	1.25
SN7430N	.20	SN74121N	.35	SN74192N	.79
SN7432N	.25	SN74122N	.39	SN74193N	.79
SN7437N	.25	SN74123N	.49	SN74194N	.89
SN7438N	.25	SN74125N	.49	SN74195N	.69
SN7439N	.25	SN74126N	.49	SN74196N	.89
SN7440N	.20	SN74132N	.75	SN74197N	.89
SN7441N	.89	SN74136N	.75	SN74198N	1.49
SN7442N	.49	SN74141N	.79	SN74199N	1.49
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SN7444N	.75	SN74143N	2.95	SN74251N	1.79
SN7445N	.75	SN74144N	2.95	SN74279N	.79
SN7446N	.69	SN74145N	.79	SN74283N	2.25
SN7447N	.59	SN74147N	1.95	SN74284N	3.95
SN7448N	.79	SN74148N	1.29	SN74285N	3.95
SN7450N	.20	SN74150N	.89	SN74365N	.69
SN7451N	.20	SN74151N	.59	SN74366N	.69
SN7453N	.20	SN74152N	.59	SN74367N	.69
SN7454N	.20	SN74153N	.59	SN74368N	.69
SN7459A	.25	SN74154N	.99	SN74390N	1.95
SN7460N	.20	SN74155N	.79	SN74393N	1.95
		SN74156N	.79		
		SN74157N	.65		

20% Discount 100 pcs combined order 25% -1000 pcs combined order

C/MOS

CD4000	.23	CD4028	.89	CD4070	.55
CD4001	.23	CD4029	1.19	CD4071	.23
CD4002	.23	CD4030	.49	CD4072	.49
CD4006	1.19	CD4035	.99	CD4076	1.39
CD4007	.25	CD4040	1.19	CD4081	.23
CD4009	.49	CD4041	1.25	CD4082	.23
CD4010	.49	CD4042	.99	CD4093	.99
CD4011	.25	CD4043	.89	CD4098	2.49
CD4012	.25	CD4044	.89	MC14409	14.95
CD4013	.39	CD4046	1.79	MC14410	14.95
CD4014	1.39	CD4047	2.50	MC14411	14.95
CD4015	1.19	CD4048	1.35	MC14419	4.95
CD4016	.49	CD4049	.49	MC14433	19.95
CD4017	1.19	CD4050	.49	MC14506	.75
CD4018	.99	CD4051	1.19	MC14507	.99
CD4019	.49	CD4053	1.19	MC14562	14.50
CD4020	1.19	CD4056	2.95	MC14583	3.50
CD4021	1.39	CD4059	9.95	CD4508	3.95
CD4022	1.19	CD4060	1.49	CD4510	1.39
CD4023	.23	CD4066	.79	CD4511	1.29
CD4024	.79	CD4068	.39	CD4515	2.95
CD4025	.23	CD4069	.45	CD4518	1.29
CD4026	2.25			CD4520	1.29
CD4027	.69			CD4566	2.25

74C00

74C00	.39	74C85	2.49	74C163	2.49
74C02	.39	74C90	1.95	74C164	2.49
74C04	.39	74C93	1.95	74C173	2.60
74C08	.49	74C95	1.95	74C192	2.49
74C10	.39	74C107	1.25	74C193	2.49
74C14	1.95	74C151	2.90	74C195	2.49
74C20	.39	74C154	3.00	74C922	5.95
74C30	.39	74C157	2.15	74C923	6.25
74C42	1.95	74C160	2.49	74C925	8.95
74C48	2.49	74C161	2.49	74C926	8.95
74C73	.89			80C95	1.50
74C74	.89			80C97	1.50

LINEAR

78MG	1.75	LM340K-18	1.35	LM710N	.79
LM106H	.99	LM340K-24	1.35	LM711N	.39
LM300H	.80	LM340T-5	1.25	LM723N/H	.55
LM301CN/H	.35	LM340T-6	1.25	LM733N	1.00
LM302H	.75	LM340T-8	1.25	LM739N	1.19
LM304H	1.00	LM340T-12	1.25	LM741CN/H	.35
LM305H	.60	LM340T-15	1.25	LM741-14N	.39
LM307CN/H	.35	LM340T-18	1.25	LM747N/H	.79
LM308CN/H	1.00	LM340T-24	1.25	LM748N/H	.39
LM309H	1.10	LM358N	1.00	LM1310N	2.95
LM309K	1.25	LM370N	1.95	LM1458CN/H	.59
LM310CN	1.15	LM373N	3.25	MC1488N	1.95
LM311N/H	.90	LM377N	4.00	MC1489N	1.95
LM312H	1.95	LM380N	1.25	LM1496N	.95
LM317K	6.50	LM380CN	.99	LM1556V	1.75
LM318CN/H	1.50	LM381N	1.79	MC1741SCP	3.00
LM319N	1.30	LM382N	1.79	LM2111N	1.95
LM320K-5	1.35	NE501N	8.00	LM2901N	2.95
LM320K-5.2	1.35	NE510A	6.00	LM3053N	1.50
LM320K-12	1.35	NE529A	4.95	LM3065N	1.49
LM320K-15	1.35	NE531H/V	3.95	LM3900N(3401)	.49
LM320K-18	1.35	NE536T	6.00	LM3905N	.89
LM320K-24	1.35	NE540L	6.00	LM3909N	1.25
LM320T-5	1.25	NE544N	4.95	MC5558V	.59
LM320T-5.2	1.25	NE550N	1.30	8038B	4.95
LM320T-8	1.25	NE555V	.39	LM75450N	.49
LM320T-12	1.25	NE556N	.99	75451CN	.39
LM320T-15	1.25	NE560B	5.00	75452CN	.39
LM320T-18	1.25	NE561B	5.00	75453CN	.39
LM320T-24	1.25	NE562B	5.00	75454CN	.39
LM323K-5	5.95	NE565N/H	1.25	75491CN	.79
LM324N	1.80	NE566CN	1.75	75492CN	.89
LM339N	.99	NE567V/H	.99	75493N	.89
LM340K-5	1.35	NE570N	4.95	75494CN	.89
LM340K-6	1.35	LM703CN/H	.69	RC4136	1.25
LM340K-8	1.35	LM709N/H	.29	RC4151	5.95
LM340K-12	1.35			RC4194	5.95
LM340K-15	1.35			RC4195	4.49

74LS00TTL

74LS00	.23	74LS47	.69	74LS138	.69
74LS01	.23	74LS51	.23	74LS139	.69
74LS02	.23	74LS54	.23	74LS151	.69
74LS03	.23	74LS55	.23	74LS155	.69
74LS04	.29	74LS73	.35	74LS157	.69
74LS05	.29	74LS74	.35	74LS160	.89
74LS08	.23	74LS75	.49	74LS161	.89
74LS09	.29	74LS76	.35	74LS162	.89
74LS10	.23	74LS78	.39	74LS163	.89
74LS11	.60	74LS83	.75	74LS164	.89
74LS13	.49	74LS85	.99	74LS175	.79
74LS14	.99	74LS86	.35	74LS181	2.49
74LS15	.29	74LS90	.49	74LS190	.89
74LS20	.23	74LS92	.59	74LS191	.89
74LS21	.29	74LS93	.59	74LS192	.89
74LS22	.29	74LS95	.79	74LS193	.89
74LS26	.29	74LS96	.89	74LS194	.89
74LS27	.29	74LS107	.35	74LS195	.89
74LS28	.29	74LS109	.35	74LS253	.79
74LS30	.23	74LS112	.35	74LS257	.69
74LS32	.29	74LS123	.99	74LS258	1.39
74LS37	.35	74LS125	.69	74LS260	.55
74LS40	.29	74LS132	.79	74LS279	.59
74LS42	.69	74LS136	.39	74LS367	.59
				74LS368	.59
				74LS670	1.95

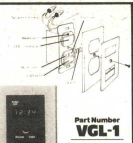
Vigilite

Electronic Home Security Timer

A microprocessor-based pre-programmed light control that fits into a home wall socket, replacing the standard on/off light switch. Discourages intruders and burglars by turning lights on and off in a "real-life" pattern while you're away.

Unlike other electromechanical timers Vigilite can simulate the lighting patterns of five different rooms as selected by the user. Vigilite can also control over-head lights, which other timers cannot. Three Vigilite units, simulating kitchen, bathroom, and bedroom lighting can give a home ultimate protection, because the user chooses a lighting pattern that depicts his real life pattern. He then sets the Vigilite clock and room pattern accordingly. (See bar chart below.) The house actually looks occupied, although no one is home.

Easy to install, the Vigilite unit contains an accurate digital LED clock, plus pre-programmed independent lighting patterns for bedroom, bathroom, kitchen, living room, and outside porch lights. All-solid-state components assure the user long product life and reliability.



Part Number VGL-1

$39.95 ea.

Technical Specifications

1) Electrical requirement—120 VAC, 60Hz, 2½ Amps.
2) For use with permanently installed incandescent 40 W to 300 W light fixtures—single pole circuits.
3) Cannot be used to control television, appliances, or other motor driven equipment.
4) One vigilite unit required for each room circuit

DISCRETE LEDS

.200" dia.			.125" dia.		
XC556R	red	5/$1	XC209R	red	5/$1
XC556G	green	4/$1	XC209G	green	4/$1
XC556Y	yellow	4/$1	XC209Y	yellow	4/$1
XC556C	clear	4/$1			
.200" dia.			.185" dia.		
XC22R	red	5/$1	XC526R	red	5/$1
XC22G	green	4/$1	XC526G	green	4/$1
XC22Y	yellow	4/$1	XC526Y	yellow	4/$1
.170" dia.			XC526C	clear	4/$1
MV10B	red	4/$1			
.085" dia.			.190" dia.		
MV50	red	6/$1	XC111R	red	5/$1
INFRA-RED LED 1/4"x1/4"x1/16" flat		5/$1	XC111G	green	4/$1
			XC111Y	yellow	4/$1
			XC111C	clear	4/$1

TIMEX T1001
LIQUID CRYSTAL DISPLAY
FIELD EFFECT

4 DIGIT – .5" CHARACTERS
THREE ENUNCIATORS
2.00" X 1.20" PACKAGE
INCLUDES CONNECTOR

T1001-Transmissive	$7.95
T1001A-Reflective	8.25

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	.270	2.95	MAN 6730	Common Anode-red ± 1	.560	.99
MAN 2	5 x 7 Dot Matrix-red	.300	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.99	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.99	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.99	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
MAN 4610	Common Anode-orange	.300	.99	DL750	Common Cathode-red	.600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL338	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	1.30
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	2.10
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.800	2.10
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 Sgl. Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character (±1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA2023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.49
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	.75
DM8889	.75
9374 7 seg. C.A. LED driver	1.50

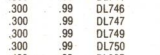
CLOCK CHIPS

MM5309	$4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
MM5841	9.95

MOTOROLA

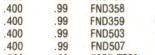
MC1408L7	$4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS



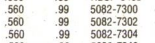
	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$.17	.16	.15	22 pin LP	$ .37	.36	.35
14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)



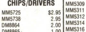
14 pin ST	$.27	.25	.24	28 pin ST	$ .99	.90	.81
16 pin ST	.30	.27	.25	36 pin ST	1.39	1.26	1.15
18 pin ST	.35	.32	.30	40 pin ST	1.59	1.45	1.30
24 pin ST	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)



8 pin SG	$.30	.27	.24	24 pin SG	$ .70	.63	.57
14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.65	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3



8 pin WW	$.39	.35	.31	22 pin WW	$ .95	.85	.75
10 pin WW	.45	.41	.37	24 pin WW	1.05	.95	.85
14 pin WW	.42	.38	.37	28 pin WW	1.40	1.25	1.10
16 pin WW	.43	.42	.41	36 pin WW	1.59	1.45	1.30
18 pin WW	.75	.68	.62	40 pin WW	1.75	1.55	1.40

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea.	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	50 PCS	$1.75
ASST. 2	5 ea.	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	50 PCS	1.75
ASST. 3	5 ea.	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	50 PCS	1.75
ASST. 4	5 ea.	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	50 PCS	1.75
ASST. 5	5 ea.	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	50 PCS	1.75
ASST. 6	5 ea.	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	50 PCS	1.75
ASST. 7	5 ea.	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

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AY-5-9100	Push Button Telephone Dialler	$14.95
AY-5-9200	Repertory Dialler	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	14.95
HD0165	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	9.95

ICM CHIPS

ICM7045	CMOS Precision Timer	24.95
ICM7205	CMOS LED Stopwatch/Timer	19.95
ICM7207	Oscillator Controller	7.50
ICM7208	Seven Decade Counter	19.95
ICM7209	Clock Generator	6.95

NMOS READ ONLY MEMORIES

MCM6571	128 X 9 X 7 ASCII Shifted with Greek	13.50
MCM6574	128 X 9 X 7 Math Symbol & Pictures	13.50
MCM6575	128 X 9 X 7 Alphanumeric Control Character Generator	13.50

MISCELLANEOUS

TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	19.95
95H90	Hi-Speed Divide 10/11 Prescaler	11.95
4N33	Photo-Darlington Opto-Isolator	3.95
MK50240	Top Octave Freq. Generator	17.50
DS0026CH	5Mhz 2-phase MOS clock driver	3.75
TIL308	.27" red num. display w/integ. logic chip	10.50
MM5320	TV Camera Sync. Generator	14.95
MM5330	4½ Digit DPM Logic Block	5.95
LD110/111	3½ Digit A/D Converter Set	25.00/set

LITRONIX ISO-LIT 1
Photo Transistor Opto-Isolator
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Generates Complex Sounds
Low Power - Programmable
3.95 each

TV GAME CHIP AND CRYSTAL
AY-3-8500-1 and 2.01 MHZ Crystal (Chip & Crystal includes score display, 6 games and select angles, etc. **7.95/set**

EXAR

XR205	$3.40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1.55			XR2567	2.99
XR-L555	1.50			XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	2.85
XR567CP	.99	XR2207	3.85	XR4194	1.45
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.30	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.39	XR2212	4.35	XR4739	1.15
XR1489	1.39	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
				1N4002	100 PIV	1 AMP	12/1.00
1N746	3.3	400m	4/1.00	1N4003	200 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N752	5.6	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N757	9.0	400m	4/1.00	1N3600	50	200m	6/1.00
1N759	12.0	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	4/1.00	1N4154	35	10m	12/1.00
1N965	15	400m	4/1.00	1N4305	75	25m	15/1.00
1N5232	5.6	500m	28	1N4734	5.6	1w	28
1N5234	6.2	500m	28	1N4735	6.2	1w	28
1N5235	6.8	500m	28	1N4736	6.8	1w	28
1N5236	7.5	500m	28	1N4738	8.2	1w	28
1N5242	12	500m	28	1N4742	12	1w	28
1N5245	15	500m	28	1N4744	15	1w	28
1N456	25	40m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N458	150	7m	6/1.00	1N1184	100 PIV	35 AMP	1.70
1N485A	180	10m	5/1.00	1N1185	150 PIV	35 AMP	1.70
1N4001	50 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
				1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C38M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

PN2907 Plastic	7/1.00			2N3904	4/1.00
C106B1	.50	MJE3055	1.00	2N3905	4/1.00
MPSA05	.30	2N3392	5/1.00	2N3906	4/1.00
MPSA06	5/1.00	2N3398	5/1.00	2N4013	3/1.00
TIS97	6/1.00	PN3567	3/1.00	2N4123	6/1.00
TIS98	6/1.00	PN3568	4/1.00	PN4249	4/1.00
40409	1.75	PN3569	4/1.00	PN4250	4/1.00
40410	1.75	MPS3638A	5/1.00	2N4400	4/1.00
40673	1.75	MPS3702	5/1.00	2N4401	4/1.00
2N918	4/1.00	2N3704	5/1.00	2N4402	4/1.00
2N2219A	2/1.00	MPS3704	5/1.00	2N4403	4/1.00
2N2221A	4/1.00	2N3705	5/1.00	2N4409	5/1.00
2N2222A	5/1.00	MPS3705	5/1.00	2N5086	4/1.00
2N2369	5/1.00	2N3706	5/1.00	2N5087	4/1.00
2N2369A	4/1.00	MPS3706	5/1.00	2N5088	4/1.00
MPS2369	5/1.00	2N3707	5/1.00	2N5089	4/1.00
2N2484	4/1.00	2N3711	5/1.00	2N5129	5/1.00
2N2906	4/1.00	2N3724A	.65	PN5134	5/1.00
2N2907	5/1.00	2N3725A	1.00	PN5138	5/1.00
2N2925	5/1.00	2N3772	2.25	2N5139	5/1.00
MJE2955	1.25	2N3823	1.00	2N5210	5/1.00
2N3053	2/1.00	2N3903	5/1.00	2N5449	3/1.00
2N3055	.89	PN2222 Plastic	7/1.00	2N5951	3/1.00

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50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075
100 VOLT MYLAR FILM CAPACITORS							
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22
+20% DIPPED TANTALUMS (SOLID) CAPACITORS							
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

CIRCLE 16 ON FREE INFORMATION CARD

Rockwell AIM 65

The Head-Start in Computers

AIM 65 Technical Overview

THERMAL PRINTER
Most desired feature on low-cost microcomputer systems . . .
- Wide 20-column printout
- Versatile 5 x 7 dot matrix format
- Complete 64-character ASCII alphanumeric format
- Fast 120 lines per minute
- Quiet thermal operation
- Proven reliability

FULL-SIZE ALPHANUMERIC KEYBOARD
Provides compatibility with system terminals . . .
- Standard 54 key, terminal-style layout
- 26 alphabetic characters
- 10 numeric characters
- 22 special characters
- 9 control functions
- 3 user-defined functions

TRUE ALPHANUMERIC DISPLAY
Provides legible and lengthy display . . .
- 20 characters wide
- 16-segment characters
- High contrast monolithic characters
- Complete 64-character ASCII alphanumeric format

PROVEN R6500 MICROCOMPUTER SYSTEM DEVICES
Reliable, high performance NMOS technology . . .
- R6502 Central Processing Unit (CPU), operating at 1 MHz. Has 65K address capability, 13 addressing modes and true index capability. Simple, but powerful 56 instructions.
- Read/Write Memory, using R2114 Static RAM devices. Available in 1K byte and 4K byte versions.
- 8K Monitor Program Memory, using R2332 Static ROM devices. Has sockets to accept additional 2332 ROM or 2532 PROM devices, to expand on-board Program Memory up to 20K bytes.
- R6532 RAM-Input/Output-Timer (RIOT) combination device. Multipurpose circuit for AIM 65 Monitor functions.
- Two R6522 Versatile Interface Adapter (VIA) devices, which support AIM 65 and user functions. Each VIA has two parallel and one serial 8-bit, bidirectional I/O ports, two 2-bit peripheral handshake control lines and two fully-programmable 16-bit interval timer/event counters.

BUILT-IN EXPANSION CAPABILITY
- 44-Pin Application Connector for peripheral add-ons
- 44-Pin Expansion Connector has full system bus
- Both connectors are KIM-1 compatible

TTY AND AUDIO CASSETTE INTERFACES
Standard interface to low-cost peripherals . . .
- 20 ma. current loop TTY interface
- Interface for two audio cassette recorders
- Two audio cassette formats: ASCII KIM-1 compatible and binary, blocked file assembler compatible

ROM-RESIDENT ADVANCED INTERACTIVE MONITOR
Advanced features found only on larger systems . . .
- Monitor-generated prompts
- Single keystroke commands
- Address independent data entry
- Debug aids
- Error messages
- Option and user interface linkage

ADVANCED INTERFACE MONITOR COMMANDS

Major Function Entry
(RESET Button)—Enter and initialize Monitor
ESC—Re-enter Monitor
E —Enter and initialize Text Editor
T —Re-enter Text Editor
N —Enter Assembler
5 —Enter and initialize BASIC Interpreter
6 —Re-enter BASIC Interpreter

Instruction Entry and Disassembly
I —Enter mnemonic instruction entry mode
K —Disassemble memory

Display/Alter Registers and Memory
* —Alter Program Counter to (address)
A —Alter Accumulator to (byte)
X —Alter X Register to (byte)
Y —Alter Y Register to (byte)
P —Alter Processor Status to (byte)
S —Alter Stack Pointer to (byte)
R —Display all registers
M —Displays four memory locations, starting at (address)
(SPACE)—Display next four memory locations
/ —Alter current memory location

Manipulate Breakpoints
\# —Clear all breakpoints
4 —Toggle breakpoint enable on/off
B —Set one to four breakpoint addresses
? —Display breakpoint addresses

Control Instruction/Trace
G —Execute user's program
Z —Toggle instruction trace mode on/off
V —Toggle register trace mode on/off
H —Trace Program Counter history

Control Peripheral Devices
L —Load object code into memory from peripheral I/O device
D —Dump object code to peripheral I/O device
1 —Toggle Tape 1 control on/off
2 —Toggle Tape 2 control on/off
3 —Verify tape checksum
CTRL PRINT—Toggle Printer on/off
LF —Line Feed
PRINT—Print Display contents

Call User-Defined Functions
F1 —Call User Function 1
F2 —Call User Function 2
F3 —Call User Function 3

Text Editor Commands
R —Read lines into text buffer from peripheral I/O device
I —Insert line into text buffer from Keyboard
K —Delete current line of text
(SPACE)—Display current line of text
L —List lines of text to peripheral I/O device
U —Move up one line
D —Move down one line
T —Go to top line of text
B —Go to bottom line of text
F —Find character string
C —Change character string
Q —Quit Text Editor, return to Monitor

LOW COST PLUG-IN ROM OPTIONS
- 4K Assembler — symbolic, two-pass
- 8K BASIC Interpreter

POWER SUPPLY SPECIFICATIONS
- + 5 VDC + 5% regulated @ 2.0 amps (max)
- +24 VDC + 15% unregulated @ 2.5 amps (peak) 0.5 amps (average)

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AIM 65 (4K) $450.00 (*$15.00)
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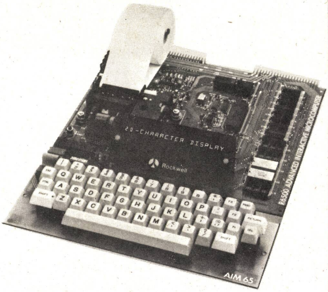

Rockwell's AIM 65 Advanced Interactive Microcomputer can get you into the exciting world of microcomputers a lot easier and at a lower cost than you may have thought possible. And you'll be working with the 6500 family, the advanced state-of-the-art NMOS system that's an everincreasing favorite for new commercial and hobbyist applications.

As a learning aid, AIM 65 gives you an assembled, versatile microcomputer system with a fullsize keyboard, 20-character display and, uniquely, a thermal printer. An on-board Advanced Interactive Monitor program provides extensive control and program development functions. And our AIM 65 User's Manual will help you along each step of the way.

You'll master fundamentals rapidly. Then you'll appreciate the fact that unlike the computer "toys" on the market, AIM 65 offers flexibility and expandability you would expect to find in a sophisticated microcomputer development system.

THERMAL PRINTER GIVES YOU HARD COPY — FAST AND QUIET.
AIM 65's 20-column Thermal Printer prints on low-cost, thermal roll paper at a fast 120 lines per minute. It produces all of the standard 64 ASCII characters with a crisp-printing five-by-seven dot matrix. AIM 65's on-board printer is a unique feature for a low-cost computer.

EXTENDED ALPHANUMERIC DISPLAY IS BUILT FOR UNDERSTANDING, NOT DECIPHERING.
AIM 65 comes with a 20-character true Alphanumeric Display. Information is displayed with bright, magnified 16-segment font monolithic characters. It's both unambiguous and easily readable.

FULL-SIZE KEYBOARD IS DESIGNED FOR HUMANS, NOT ELVES.
AIM 65's terminal-style keyboard frees you from the hassles of fumbling around with a tiny calculator-type keypad. And its 54 keys provide 70 different alphabetic, numeric, control and special functions.

ON-BOARD ADVANCED INTERACTIVE MONITOR GETS YOUR PROGRAMS UP AND RUNNING.
The ROM-resident AIM 65 Advanced Interactive Monitor Program provides a comprehensive set of easy-to-use, single-keystroke commands for debugging your programs, and offers features normally available only in larger, expensive microcomputer development systems. And with the AIM 65 Monitor, there's no guesswork involved; the Monitor gives a self-explanatory prompt when it needs information and it will generate a meaningful error message if an error has occurred.

The AIM 65 Monitor includes commands to
- Enter and edit programs directly — no "opcode" memorization
- List programs on Printer or TTY
- Display/alter registers and memory
- Set breakpoints, trace and debug program execution
- Control the Thermal Printer
- Transfer information to/from attached Cassette Recorders or TTY
- Execute programs in on-board or external RAM, ROM or PROM memory
- Interface the optional AIM 65 Assembler and BASIC Interpreter

AIM 65'S ADVANCED R6500 NMOS ARCHITECTURE.
The R6502 Central Processing Unit is the heart of the AIM 65. It provides demonstrated speed and simplicity, plus 65K addressability and the power of a 56-command, minicomputer-like instruction set.

The R6532 RAM-Input/Output-Timer (RIOT) combination device is used by the AIM 65 Monitor for scratchpad memory and Keyboard operations.

Two R6522 Versatile Interface Adapter (VIA) devices are provided. One device supports AIM 65's Thermal Printer and the TTY and Cassette Interfaces, the other supports two user-dedicated 8-line I/O ports, plus an 8-bit serial I/O port and access to two 16-bit interval timer/event counters, on the module's Application Connector.

AIM 65 comes with two R2332 4K Read Only Memory (ROM) devices installed. These hold the Advanced Interface Monitor program. Spare sockets allow the user to expand on-board ROM up to 20K bytes. These sockets will accept user programs on R2332 ROMs or compatible PROMs, or can be used to install the optional AIM 65 Assembler and BASIC Interpreter ROM devices.

On-Board Read/Write RAM memory is available in 1K-byte and 4K-byte configurations.

AIM 65 HAS EXPANSION BUILT IN.
And to allow AIM 65 to grow the way **you** want it to, we've provided an Application Connector and an Expansion Connector. The Application Connector permits you to plug on a TTY (20 ma. current loop) and one or two standard audio cassette recorders. It also has the pinouts for the VIA's General-Purpose I/O ports. The Expansion Connector extends AIM 65's system bus — address, data and control — out to additional memory, or anything else you might attach.

And, BASIC high-level language programming is a built-in option.

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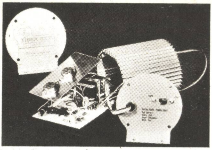

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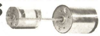

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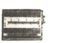

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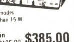

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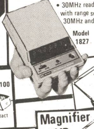

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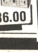

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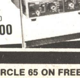

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7404	7439	7476	74166
7406	7440	7483	74175
7410	7441	7485	74177
7416	7442	7493	74180
7423	7445	7495	74182
7425	7446	7496	74190
7426	7448	74141	74195
7427	7450	74145	

$24.50

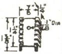
LOW POWER TTL PACKAGE

$15.00

dual-in-line package
tested functional & marked
10 each of the following

74L00	74L06	74L51	74L78
74L02	74L10	74L72	74L86
74L03	74L20	74L73	74L93
74L04	74L42	74L74	74L95

HEAT SINK



for TO-220 package
aluminum, PC mt tabs
5/$1.00 100/$15.00

TRANSISTOR PACKAGE $12.95

5 each of following

2N1132A	PNP	Gen. purpose trans.	TO-39
2N2218A	NPN	Low power trans.	TO-5
2N2219A	NPN	Low power trans.	TO-5
EN2222	NPN	Low power trans.	TO-106
2N2369	NPN	Low power trans.	TO-18
2N2904	PNP	Low power trans.	TO-5
2N3227	NPN	Low power trans.	TO-18
2N3565	NPN	Low power trans.	R-110
2N4304	FET	N Channel	R97b
SCA		400V Power trans	TO-5

LED DISPLAY SPECIALS

DL702	.30"	red	CC	LHDP	$.59
HP3400	.8"	red	CA	LHDP	.99
HP3405	.8"	red	CC	LHDP	.99
HP7651	.43"	red	CA	RHDP	.69
HP7653	.43"	red	CC	RHDP	.69

LINEAR IC PACKAGE $26.50

tested functional & marked
5 each of the following

301 mDIP op amp	380 DIP aud amp
302 TO5 V follower	565 DIP PLL
307 mDIP op amp	723 DIP V reg
308 TO5 op amp	733 TO5 vid amp
311 mDIP V comp	739 DIP dual op amp
322 DIP prec timer	741 mDIP op amp
339 DIP quad comp	748 mDIP op amp
340T 6Volt reg	3900 DIP quad amp
340T 15Volt reg	75453 mDIP dp drvr
376 mDIP V reg	75491 seg driver

14 PIN IC SOCKETS

TI low profile soldertail
10/$1.65 100/$15.00

LINEAR IC PACKAGE $15.00

tested functional & marked
5 each of the following

301 mDIP op amp	565 DIP PLL
307 mDIP op amp	739 DIP dual op amp
311 mDIP V comp	748 mDIP op amp
340T 6V reg.	1414 DIP dual comp
376 mDIP volt reg	3900 DIP quad amp

CAPACITOR PACKAGE

$3.95

polyester radial ± 10%
10 each of following values

.0047uf/100V	.022uf/100V
.015uf/100V	.033uf/100V
.018uf/100V	.047uf/200V

LINEAR CIRCUITS

LM300H	.49	LM340T (78XX) 5,6,8,12, 15,18,24	1.19	LM566CN	1.19	ULN2208	.89
LM301CN	.20	LM370	.65	LM567CN	1.19	ULN2209	.89
LM302H	.45	LM372N	2.93	LM567H	1.49	CA3046	1.19
LM304H	.80	LM376CN	.25	LM703H	.59	CA3081N	1.49
LM305H	.45	LM377N	.95	LM703CN	.39	CA3081H	1.97
LM307CN	.20	LM380N	.79	LM709N	.25	CA3082	1.45
LM307H	.30	LM380-8CN	.59	LM709H	.29	LM3900N	.35
LM308H	.39	LM381N	1.75	LM710N	.59	LM7524	.79
LM309H	1.05	LM382N	1.75	LM711N	.35	LM7525	.79
LM309K	1.05	LM385K	.25	LM723H	.55	LM7535	.45
LM310CN	1.07	LM386CN	.49	LM723N	.52	8038B	4.59
LM311CN	.40	LM387CN	.49	LM733H	.59	75450AN	.35
LM311H	.50	NE531V	1.90	LM739N	.65	75451CN	.25
LM319N	1.13	NE540L	1.90	LM741CN(8)	.25	75452CN	.25
LM320K 5,5.2,12, 15	1.29	NE546A	1.09	LM741CN(14)	.32	75453CN(351)	.25
LM320T (79XX) 5,12,15	1.19	NE550A	.75	LM741CH	.35	75454CN	.35
LM322N	.69	LM555CN	.39	LM747H	.79	75491N	.65
LM324N	.95	NE556A	.85	LM747N	.65	75492N	.75
LM339N	.69	LM560N	2.95	LM748CN	.25	XR320	1.19
LM340K 5,6,8,12, 15,18,24	1.29	LM561N	2.95	LM1310N	2.25	XR2207	1.49
		LM565N	.59	LM1414N	.60	XR2567	1.49
		LM565H	1.39	LM1456CN	1.29	XR4136	1.49
		LM566H	1.39	LM1458CN	.59	XR4202	.69
				LM1496N	.89	XR4212	.69
				LM1800N	1.75	XR4739	.69

IC'S 10% OFF ON $25.00 15% OFF ON $50.00

TANTALUM CAPACITORS

±20% solid dipped

	1-10	11-		1-10	11-
.22u/35V	.25	.20	10u/16V	.35	.30
.33v/35V	.25	.20	10u/20V	.38	.33
1u/35V	.25	.20	15u/6.3V	.38	.33
2.2u/20V	.28	.23	15u/20V	.45	.40
2.2u/35V	.30	.25	22u/16V	.45	.40
3.3u/35V	.35	.30	33u/10V	.55	.50
4.7u/16V	.30	.25	47u/6V	.55	.50
6.8u/6V	.30	.25	47u20V	.65	.55
6.8u/16V	.30	.25	56u/6V	.75	.65
6.8u/50V	.35	.30	100u/20V	1.45	

cylindrical (axial)

	1-10	11-
.68u/15V	.20	.15
15u/25V	.40	.35

TRIMPOT PACKAGE $11.95

miniature cermet
single turn, Mepco 8014
2 each of following values
500 ohm, 1K, 2K, 5K, 10K,
20K, 50K, 100K, 500K, 1M

CAPACITOR PACKAGE $7.95

electrolytic - axial
5 each of following

.1uf/200V	22uf/50V
1uf/16V	100uf/10V
2.2uf/25V	150uf/25V
5uf/25V	220uf/25V
10uf/50V	500uf/30V

shipping & handling
US, Canada & Mexico $1.00
Other countries $2.50

TTL - 7400

7491	.64	7400	.10	7441	.75	74163	.75
7492	.39	7401	.15	7442	.35	74164	.65
7493	.39	7402	.14	7443	.45	74165	.75
7494	.59	7403	.12	7444	.60	74166	.95
7495	.59	7404	.14	7445	.50	74170	1.50
7496	.49	7405	.17	7446	.55	74173	1.25
74100	.89	7406	.15	7447	.55	74174	1.05
74105	.38	7407	.15	7448	.60	74175	.65
74107	.25	7408	.18	7450	.15	74176	.70
74121	.29	7409	.15	7451	.15	74177	.70
74123	.32	7410	.10	7453	.13	74180	.40
74125	.45	7411	.19	7454	.10	74181	1.95
74126	.40	7413	.30	7460	.10	74182	.70
74132	.60	7414	.55	7464	.20	74185	1.85
74141	.70	7415	.22	7465	.20	74190	.95
74145	.70	7416	.14	7470	.27	74191	.85
74150	.89	7417	.20	7472	.30	74192	.50
74151	.50	7420	.14	7473	.29	74193	.50
74153	.50	7423	.28	7474	.18	74194	.85
74154	.95	7425	.32	7475	.42	74195	.50
74155	.55	7426	.15	7476	.29	74196	.80
74156	.40	7427	.20	7480	.17	74197	.75
74157	.45	7430	.17	7483	.58	74198	1.40
74158	.55	7432	.15	7485	.75	74199	1.25
74160	.65	7437	.15	7486	.27	74S200	3.25
74161	.60	7438	.15	7489	1.25	74279	.65
74162	.95	7440	.13	7490	.35		

DISCRETE LED's

ME4 Infra-red emitter .17" radial	5/$1
MV10B clear red lite .17" radial	6/$1
MV50 clear red lite .09" axial	15/$1
NSL100 red .19" radial	10/$1
Subminn. red .125" (RL209)	10/$1
Subminn. green .125"	8/$1
Subminn. clear red lite .125"	8/$1
Subminn. white red lite .125"	10/$1
White red lite .160" (RL203)	10/$1
Jumbo red .200"	10/$1
Jumbo green .200"	7/$1
Jumbo yellow .200"	7/$1
Jumbo clear .200"	10/$1
Jumbo red .200" current reg.	10/$1

BUMPONS

white vinyl pads
peel & stick
.53" sq. X .23" high
12/$1.00 100/$5.00

CERAMIC DISC CAPACITORS - 50V

1pf	22pf	56pf	120pf	270pf	820pf	.022uf
5pf	27pf	68pf	150pf	390pf	.001uf	.030uf
7pf	33pf	82pf	180pf	470pf	.0047uf	.050uf
10pf	47pf	100pf	220pf	600pf	.01uf	.1uf

	1pf-.050u	.1uf
1-10 per value	$.10	$.15
11-100	.05	.10
100-	.04	.08

ELECTRONIC BUZZER

Miniature, Solid State
6V 15ma (4-9V oper.) $1.29 ea.
12V 15ma (8-20V oper.) $1.29 ea.

CERAMIC CAPACITOR ASSORTMENT - 50V

1pf	33pf	82pf	220pf	820pf	.022uf
5pf	47pf	100pf	270pf	.001uf	.030uf
10pf	56pf	150pf	470pf	.0047uf	.050uf
22pf	68pf	180pf	600pf	.01uf	.1uf

10ea of above values.......$11.95
Supplied in steel cabinet with clear styrene drawers............$19.95
Cabinet shipping chrg (US & Canada)..........$2.00

TANTALUM CAPACITOR KIT

solid dipped, 12 values, 5 each

.1uf/35V	2.2/35	10/25	33/10
.33/35	4.7/16	15/20	47/25
1/35	6.8/16	22/16	56/6

capacitors only......$14.95

SUMMER CIRCUITS ELEKTOR 78

Double issue containing more than 100 circuits - such as high-perf. disc pre-amp, Audio control ampl., LED level indicator, Car ammeter, Bike speedometer, A/D converter and many more.

with order $3.00
mag only 4.25

ELEKTOR MAGAZINE SPECIAL $4.00

1 each of back issue No. 25, 26, 29, 30, & 31 + $1 shipping & handling
Includes articles on:

- ELEKTOR music synthesiser
- Surround sound
- Stereo encoder
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- Microprocessors
- Logarithmic dark room timer
- TV pattern generator
- Kirlian photography
- Biorythm program & calendar
- Infra red stereo transmitter
- Ioniser
- Magnetiser
- Video bio feedback

available only in U S UPS delv only

LM311N, LM311CN Volt. comparator	$ .29
LM739N Dual hi perf op amp	.59
LM1414N Dual diff comp	.49
LM3900N Quad op amp	.29
XR4136N Quad op amp	.79
SL-5-4025 Quad 25bit shift reg.	.50
2510 Dual 100bit static shift shift register	.50
2511 Dual 200bit static shift register	.65
2513 64x8x5 Char gen upper case	3.95
2513 64x8x5 Char gen lower case	3.95
2516 64x6x8 Char gen ASCII	6.95
F93410 256bit RAM bi-polar	.95
74S200 (82S16) 256bit RAM tri-state	2.75
8008 8 bit microprocessor	9.95
LD110/111 set 3 1/2 digit A/D convert	17.95
F7001 Calendar clock	4.95
TR1602 UART	3.95

IC SOCKETS

Low Profile Solder Tail				Wire Wrap	
8 pin	$.16	24 pin	$.36	8 pin	.45
14 pin	.19	28 pin	.44	14 pin	.49
16 pin	.21	40 pin	.61	16 pin	.55
18 pin	.28				

BEZELS - with red filters

140-2 cut-out 1.125" x 2.375" max .062" panel thickness $1.75
140-4 cut-out 1.160" x 4.375" max .125" panel thickness $2.75

SIGNAL DIODES | silicon, 400mw 25/$1 200/$5

LED DISPLAY

DL10A	.27" Red CA LHD	.79
MAN66	.60" Red CA LHD	1.19
DL33B	2 Dig .17" Red CC	.29
DL33B	3 Dig .17" Red CC	.49
NSN33	3 Dig .17" Red CC	.39
MAN72	.30" Red CA LHD	.59
MAN74	.30" Red CC RHD	.59
NSN74R	.30" Red CC RHD	.59
MAN82	.30" Yellow CA LHD	.69
DL702	.30" Red CC LHD	.69
HP7651	.5" Red CA RHD	.79
HP7653	.5" Red CC RHD	.79
HP3400	.8" Red CA LHD	1.25
HP3405	.8" Red CC LHD	1.25
MAN3620	.30" Orange CA LHD	.79
MAN3630	.30" ±1 Orange CA RHD	.49
MAN4610	.40" Orange CC RHD	.59
HP5082	5 dig .11"mag. Red CC RHD	.49
HP5082	4 dig .11"mag. Red CC RHD	.39
HP5082	5 dig .11"mag. Red CC CD	.49

METAL FILM RESISTORS

Rohm QUALITY RELIABILITY

± 1%, 1/4w, ± 50 PPM/°C
Standard Decade Values 10.5 - 464K

Qty.	Ea.	Min 10/value	Min 100/value
1-99	$.20	$.15	
100-999	.20	.10	$9.00/100
1000-			8.00/100

Carbon Film Fesistors ± 5% 1/4w, 1/2w

Qty.	Ea.	Min 10/value	Min 100/value
1-99	$.10	$.05	
100-999	.10	.04	$3.00/100
1000-			2.50/100

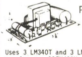
Carbon Film ± 5% 1/4 w or 1/2 w
15 ea. of 12 values:
100, 220, 470, 1K, 1.5K, 3.3K
4.7K 6.8K, 10K, 33K, 100K, 1M.
$5.45

PRECISION RESISTOR PACKAGE

Rohm

Metal film, ±1%, 1/4w, 50ppm
240 resistors, 4 ea. from 10.5 to 464K $27.95
Supplied in steel cabinet with clear stryene drawers $39.50
Cabinet shipping chrg, US & Can.$2.00

REGULATED POWER SUPPLY



Uses 3 LM340T and 3 LM320T regulators, 115V/29V CT transformer plus PC board capacitors & diodes. All parts, schematic, instructions
PS-29...........$12.95 + $1.00 Shppng.

TRIMPOT - Single Turn

SINGLE TURN, 1/4" dia, .150" height
Mepco/Electra Series 8014 (ET14)
.5w ± 100ppm/°C ± 20%

available sizes
500 Ohm, 2K, 10K, 20K, 50K, 100K, 500K, 1M

1-9	10-99	100-999	1000-
$.75ea	.69	.63	.57

PRECISION RESISTOR PACKAGE

Metal Film ± 1% 1/4 watt
Starter Kit - 2ea. 60 values
120 Resistors 10.5 ohm- 464K
$14.95
Supplied in 15 Drawer 60 Comp. Cabinet - $26.50 + $2.00 Sh.

I C BREADBOARD

Silver plated copper circuits holds 5 - 16 pin DIP IC's and interconnection holes. $1.00

UNIVERSAL BREADBOARD

Silver placed copper circuits fits any IC and related components. 2 triple rows of 27 holes for DIP. 3-3/16"x5-1/16" $1.00

VECTOR BOARD - Phenolic

169P44-062 (.1"spacing .42" dia.)
4-1/4" x 4-1/2" x .0625"...$1.15 ea.

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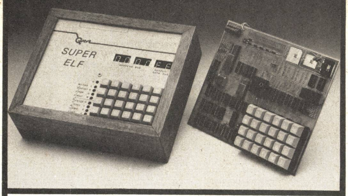

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Same day shipment. First line parts only. Factory tested. Guaranteed money back. Quality IC's and other components at factory prices.

QUEST Cosmac Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded** with **additional memory, Tiny Basic, Ascii Keyboards, video character generation, etc.**

The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during** and **after** executing instructions. Also, CPU mode and instruction cycle are shown on several LED indicator lamps.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, input, memory protect, memory select, monitor select** and **single step.** Large, on board displays provide output and optional **high and low address**. There is a 44 pin standard connector for PC cards and a 50 pin connector for the **Quest Super Expansion Board.** Power supply and sockets for **all** IC's are included in the price plus a detailed 90 page instruction manual.

Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and research and development.

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Hardwood Cabinet** with drilled and labelled front panel **$24.95. NiCad Battery Backup Kit $4.95.** All kits and options also come completely assembled and tested.

Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year.

Tiny Basic for ANY 1802 System

Cassette $10.00. On ROM Monitor $38.00. Super Elf owners, 30% off. **Object code listing or paper tape with manual $5.50. Original ELF Kit Board $14.95.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface**. Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf**. The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed** ($12.00 value). EPROM can be used for the monitor and Tiny Basic or other purposes.

A IK Super ROM Monitor $19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatable cassette file) another exclusive from Quest. It includes register save and readout, video graphics driver with blinking cursor and block move capability. The Super Monitor is written with subroutines allowing users to take advantage of monitor functions simply by calling them up. Improvements and revisions are easily done with the monitor. If you have the **Super Expansion Board** and **Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports** with **full handshake**. They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. A Godbout 8K RAM board is available for $127.95. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $12.50 for easy connection between the **Super Elf** and the **Super Expansion Board.**

The **Power Supply** for the Super Expansion Board is a 5 amp supply with + 8v ± 18v + 12v – 5v. Regulated voltages are +5v & +12v $29.95. Deluxe version includes the case at $39.95.

INTEGRATED CIRCUITS

7400TTL	
7400N	.17
7402N	.17
7404N	.19
7409N	.23
7410N	.17
7414N	.63
7420N	.17
7422N	1.39
7430N	.20
7442N	.50
7445N	.69
7447N	.60
7448N	.69
7450N	.17
7474N	.29
7475N	.49
7485N	.88
7489N	2.00
7490N	.43
7492N	.43
7493N	.43
7495N	.69
74100N	.90
74107N	.29
74121N	.34
74123N	.59
74125N	.39
74145N	.69
74150N	.95
74151N	.69
74154N	1.00
74157N	.69
74161N	.87
74162N	.87
74163N	.87
74174N	.96
74175N	.90
74190N	1.15
74192N	.87
74193N	.85
74221N	1.55
74298N	1.65
74365N	.66
74366N	.66
74367N	.66

74LS00 TTL	
74LS00N	.25
74LS02N	.25
74LS04N	.25
74LS05N	.25
74LS08N	.25
74LS10N	.25
74LS13N	.40
74LS14N	.90
74LS20N	.25
74LS22N	.25
74LS28N	.41
74LS30N	.25
74LS33N	.39
74LS38N	.30
74LS74N	.35
74LS75N	.47
74LS90N	.51
74LS93N	.51
74LS95N	1.89
74LS107N	.35
74LS112N	.35
74LS113N	.35
74LS132N	.72
74LS136N	.35
74LS151N	.67
74LS155N	.67
74LS157N	.67
74LS162N	.91
74LS163N	.91
74LS174N	.95
74LS190N	1.06
74LS221N	1.95
74LS258N	.67
74LS367N	.89

LINEAR	
CA3045	.90
CA3046	.67
CA3081	1.80
CA3082	1.90
CA3089	2.95
LM301AN/AH	.35
LM305H	.87
LM307N	.35
LM308N	.89
LM309H	1.15
LM309K	.95
LM311H/N	.90
LM317T/K	2.92
LM318	1.35
LM320K-5	1.20
LM323K-5	6.95
LM320K-12	1.35
LM320K-15	1.35
LM320T-5	1.60
LM320T-8	1.60
LM320T-12	1.50
LM320T-15	1.60
LM324N	1.15
LM339N	1.55
LM340K-5	1.10
LM340K-8	1.10
LM340K-12	1.10
LM340K-15	1.10
LM340K-24	1.10
LM340T-5	1.10
LM340T-8	1.10
LM340T-12	1.10
LM340T-15	1.10
LM340T-18	1.10
LM340T-24	1.10
LM343H	4.50
LM370	1.15
LM377	4.50
LM379	5.00
LM380N	1.00
LM381	1.60
LM382	1.60
LM703H	.40
LM709H	.28
LM723H/N	.50
LM733N	.67
LM741CH	.35
LM741N	.25
LM747H/N	.62
LM748N	.35
LM1303N	.82
LM1304	1.10
LM1305	1.27
LM1307	2.00
LM1310	2.75
LM1458	.47
LM1800	1.75
LM1812	7.50
LM1889	3.00
LM2111	1.75
LM2902	1.50
LM3900N	.60
LM3905	1.75
LM3909N	.61
MC1458V	.50
NE540L	2.89
NE550N	.65
NE555V	.43
NE556A	.79
NE565A	1.00
NE566V	1.50
NE567V	1.20
NE570B	5.00
NE571B	5.00
78L05	.60
78L08	.60
79L05	.70
78M05	.85
75108	1.75
75491CN	.50
75492CN	.55
75494CN	.89

A to D CONVERTER	
8038B	4.50
8700CJ	13.95
8701CN	22.00
8750CJ	13.95
LD130	9.95
9400CJV/F	7.40
ICL7103	9.50
ICL7107	14.25

CMOS	
CD34001 Fair.	.50
CD4000	.16
CD4001	.21
CD4002	.21
CD4006	1.10
CD4007	.21
CD4008	.21
CD4009	.39
CD4010	.39
CD4011	.21
CD4012	.21
CD4013	.36
CD4014	.86
CD4015	.86
CD4016	.36
CD4017	.94
CD4018	.94
CD4019	.21
CD4020	1.02
CD4021	1.02
CD4022	.86
CD4023	.21
CD4024	.75
CD4025	.21
CD4026	1.51
CD4027	.36
CD4028	.79
CD4029	1.02
CD4030	.21
CD4035	1.02
CD4040	1.02
CD4042	.71
CD4043	.63
CD4044	.63
CD4046	1.67
CD4049	.36
CD4050	.36
CD4051	1.13
CD4060	1.42
CD4066	.71
CD4068	.40
CD4069	.40
CD4070	.40
CD4071	.21
CD4072	.21
CD4073	.21
CD4075	.21
CD4076	1.75
CD4078	.40
CD4081	.21
CD4082	.21
CD4116	.47
CD4490	5.50
CD4507	1.00
CD4508	4.25
CD4510	1.02
CD4511	.94
CD4515	2.52
CD4516	1.10
CD4518	1.02
CD4520	1.02
CD4527	1.51
CD4528	.79
CD4553	5.75
CD4566	2.25
CD4583	4.50
CD4585	1.10
CD40192	3.00
74C00	.28
74C04	.33
74C10	.28
74C14	2.10
74C20	.28
74C30	.28
74C48	1.95
74C74	.75
74C76	1.40
74C90	1.15
74C93	1.40
74C154	3.00
74C160	1.44
74C175	1.35
74C192	1.65
74C221	2.00
74C905	3.00
74C906	.75
74C914	1.95
74C922	5.50
74C923	5.50
74C925	6.95
74C926	6.95
74C927	6.95

INTERFACE	
8095	.65
8096	.65
8097	.86
8098	.65
8T09	1.25
8T10	4.50
8T13	3.00
8T20	5.50
8T23	3.10
8T24	3.50
8T25	3.20
8T26	1.69
8T28	2.75
8T97	1.69
8T98	1.69

MOS/MEMORY RAM	
2101-1	3.95
2102-1	.95
2102AL-4	1.60
21F02	1.25
2104A-4	4.95
2107B	4.95
2111-1	3.75
2112-2	3.95
2114	8.50
4116	17.95
2513B	6.30
21L02-1	1.49
MM5262	.40
MM5280	3.00
MM5320	9.95
MM5330	5.94
PD411D-3	4.00
PD411D-4	5.00
P5101L	13.95
4200A	9.95
82S25	2.90
91L02A	1.75
HD0165-5	6.95
MM57100	4.50
GIAY38500-1	9.95
MCM6571A	9.95
9368	3.50
410D	10.00
416	16.00

CLOCKS	
MM5309	3.00
MM5311	3.60
MM5312	4.80
MM5313	3.60
MM5314	3.90
MM5315	4.00
MM5316	5.00
MM5318	3.60
MM5369	2.10
MM5841	14.45
MM5865	7.95
CT7001	5.80
CT7002	8.95
CT7010	8.95
CT7015	7.25
MM5375AA/N	3.90
MM5375AB/N	4.90
7205	16.50
7207	7.50
7208	15.95
7209	4.95
DS0026CN	3.75
DS0056CN	3.75
MM53104	2.50

MICROPROCESSOR	
6800	17.50
6802	24.95
8080A with data	8.95
8085	27.00
Z80	29.95
8212	2.90
8214	8.00
8216	2.90
8224	2.90
8228	5.35
8251	8.50
8253	10.00
8255	9.25
8257	19.50
8259	19.50
CDP1802CD	19.95
CDP1802D	25.00
CDP1861	12.95
6820	9.95
6850	12.95
6502	12.50

IC SOCKETS

Solder Tin PIN	1 UP	Low Profile PIN	1UP
8	.15	22	.30
14	.18	24	.35
16	.20	28	.42
18	.27	36	.58
20	.29	40	.57

3 level wire wrap gold.
14 pin .25 16 pin .27
2 level 14 pin ww .20

WIRE WRAP LEVEL 3

PIN		PIN	
14	.25	24	.86
16	.27	28	1.00
18	.57	40	1.23

UART/FIFO	
AY5-1013	5.50
AY5-1014	7.50
3341	6.95

PROM	
1702A	3.95
N82S23	2.95
N82S123	3.50
N82S126	3.75
N82S129	3.75
N82S131	3.75
N82S136	8.75
N82S137	8.75
2708	12.50
DM8577	2.90
8223	2.90
2716T1	22.50
2716 Intel	48.00

CRYSTALS	
1 MHz	4.50
2 MHz	4.50
4 MHz	4.25
5 MHz	4.25
10 MHz	4.25
18 MHz	3.90
20 MHz	3.90
32 MHz	3.90
32768 MHz	4.00
1.8432 MHz	4.50
3.5795 MHz	1.20
2.0100 MHz	1.95
2.097152 MHz	4.50
2.4576 MHz	4.50
3.2768 MHz	4.50
5.0688 MHz	4.50
5.185 MHz	4.50
5.7143 MHz	4.50
6.5536 MHz	4.50
14.31818 MHz	4.25
18.432 MHz	4.50
22.1184 MHz	4.50

CONNECTORS	
44 pin edge	2.00
100 pin edge	4.50
100 pin edge WW	5.25

KEYBOARD ENCODERS	
AY5-2376	$12.50
AY5-3600	13.50
74C922	5.50
74C923	5.50
HD0165-5	8.95

IC Test Clips	1	10
Red	.55	.47
Black	.55	.47

Keyer 8043 14.50
comp. w/spec./sock.

TRANSISTORS	
2N2222A	.18
2N3904	.18
2N3906	.18
2N3055	.69

CLOCK MODULES Complete alarm clocks ready to hook up with transformer and switches. Very compact with .50" and .84" digits.

MA1002A, C or E .50"	8.95
102P3 Transformer	2.25
MA1010A, C or E .84"	11.95
102P2 Transformer	2.25
Special transformer and six switches when purchased w/module	2.95
MA1003 car module .3" green fluor. display	15.95

RESISTORS ¼ watt 5%
10 per type .03 1000 per type .012
25 per type .025 350 piece pack
100 per type .015 5 per type 6.75

KEYBOARDS	
56 key ASCII keyboard kit	$62.50
Fully assembled	72.50
53 key ASCII keyboard kit	55.00
Fully assembled 65.00 Enclosure	14.95

LEDS	
Red TO18	.15
Green, Orange, Yellow TO18	.20
Jumbo Red	.20
Green, Orange, Yellow Jumbo	.25
Cliplite LED Mounting Clips	8/$1.25

(specify red, amber, green, yellow, clear)

CONTINENTAL SPECIALTIES in stock
Complete line of breadboard test equip.
MAX-100 8 digit Freq. Ctr. $128.95

OK WIRE WRAP TOOLS in stock
Portable Multimeter $18.00

DIGITAL THERMOMETER $48.50
Batt. oper. General purpose or medical 32°–230°F. Disposable probe cover ±.2° accuracy. Comp. Assy. in compact case.

COMPUTER BOARD KITS	
8K RAM Board Kit	$134.95
4K EPROM Kit	114.95
I/O Board Kit	44.50
Extender Board w/connector	12.50
Video Interface board kit	125.00
16K EPROM board kit w/o PROMS	74.50
16K Static RAM board kit	395.00
North Star Floppy Disk Kit	**$665.00**
Additional Drive Kit	415.00

SPECIAL PRODUCTS	
MM5865 Stopwatch Timer	9.00
PC board	7.50
Switches Mom. Pushbutton	.27
3 pos. slide	.25
Encoder HD0165-5	6.95
3 Digit Universal Counter Board Kit Operates 5–18 Volt DC to 5 MHz typ. .125" LED display	**10.50**
Voice actuated switch	.50
Paratronics 100A Logic Analyzer Kit	**$224.00**
Model 10 Trigger Expander Kit	$229.00
Model 150 Bus Grabber Kit	$369.00

TRANSFORMERS	
6V 300 ma	3.25
12 Volt 300 ma transformer	1.25
12.6V CT 600 ma	3.75
12V 250 ma wall plug	2.95
12V CT 250 ma wall plug	3.50
24V CT 400 ma	3.95
10V 1.2 amp wall plug	4.85
18V 6 amp	12.95

DISPLAY LEDS			
MAN1	CA	.270	2.90
MAN3	CC	.125	.39
MAN72/74	CA/CA	.300	1.00
DL704	CC	.300	1.25
DL707/DL707R	CA	.300	1.00
DL727/728	CA/CC	.500	1.90
DL747/750	CA/CC	.600	1.95
DL750	CC	.600	1.95
FND359	CC	.357	.70
FND500/507	CC/CA	.500	1.35
FND503/510	CC/CA	.500	.90
FND800/807	CC/CA	.800	2.20
3 digit Bubble			.60
4 digit bubble			.80
DG8 Fluorescent			1.75
DG10 Fluorescent			1.75
5 digit 14 pin display			1.00
NSN69 9 digit display			.60
7520 Clairex photocells			.39
TIL311 Hex			9.50

COMPUTER GRADE CAPS			
1600	mfd	200V	4.50
2000	mfd	45V	2.50
3200		50V	2.50
5500		25V	2.50
5800		40V	3.00
6100		40V	3.00
6100		50V	3.00
7700		50V	2.50
8000		55V	2.50
9400		65V	3.00
10000		20V	2.50
12000		30V	3.50
35000		25V	5.00
55000		25V	5.00
82000		15V	6.00
160000		10V	6.00

Auto Clock Kit $15.95

DC clock with 4-.50" displays. Uses National MA-1012 module with alarm option. Includes light dimmer, crystal timebase PC boards. Fully regulated, comp. instructs. Add $3.95 for beautiful dark gray case. Best value anywhere.

RCA Cosmac VIP Kit 229.00

Video computer with games and graphics.

Not a Cheap Clock Kit $14.95

Includes everything except case. 2-PC boards. 6-.50" LED Displays. 5314 clock chip, transformer, all components and full instructions. Green and orange displays also avail. **Same kit w/.80" displays.** Red only. **$21.95**

60 Hz Crystal Time Base Kit $4.40

Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy. Kit includes: PC board, MM5369, crystal, resistors, capacitors and trimmer.

Digital Temperature Meter Kit

Indoor and outdoor. Switches back and forth. Beautiful. 50" LED readouts. Nothing like it available. Needs no additional parts for complete, full operation. Will measure −100° to +200°F, tenths of a degree, air or liquid. Very accurate. **$39.95**
Beautiful hardwood case w/bezel **$11.75**

NiCad Battery Fixer/Charger Kit

Opens shorted cells that won't hold a charge and then charges them up, all in one kit w/full parts and instructions. **$7.25**

PROM Eraser

Ultraviolet, assembled **$49.95**

Clock Calendar Kit $23.95

CT7015 direct drive chip displays date and time on .6" LEDS with AM-PM indicator. Alarm/doze feature includes buzzer. Complete with all parts, power supply and instructions, less case.

Sinclair 3½ Digit Multimeter

Batt./AC oper. 1mV and .1NA resolution. Resistance to 20 meg. 1% accuracy. Small, portable, completely assem. in case. 1 yr. guarantee. Best value ever! **$59.95**

Video Modulator Kit $8.95

Convert your TV set into a high quality monitor without affecting normal usage. Complete kit with full instructions.

2.5 MHz Frequency Counter Kit

Complete kit less case **$37.50**

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Complete kit less case **$47.75**
Prescaler kit to 350 MHz **$19.95**

1978 IC Update Master Manual

1978 IC Update Master Manual **$30.00.** Complete IC data selector, 2175 pg. Master reference guide. Over 42,000 cross references. Free update service through 1978. Domestic postage $3.50. Foreign $6.00.

Stopwatch Kit $26.95

Full six digit battery operated. 2–5 volts. 3.2768 MHz crystal accuracy. Times to 59 min., 59 sec., 99 1/100 sec. Times std., split and Taylor. 7205 chip, all components minus case. Full instructions.

D Connectors RS232

25 Pin Subminiatures

DB25P	2.95	DE9P	1.50
DB25S	3.95	DE9S	1.95
Cover	1.50	DA15P	2.10
RS232 Complete Set	6.50	DA15S	3.10

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8K Static RAM Kit	$127.00
16K Static RAM Kit	265.00
24K Static RAM Kit	423.00
32K Dynamic RAM Kit	449.00
64K Dynamic RAM Kit	945.00
8K/16K Eprom Kit (less PROMS)	**$89.00**
Video Interface Kit	**$139.00**
Motherboard **$39.** Extender Board	**$8.99**

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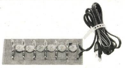
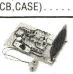
*Perforated Boards **NOT INCLUDED** w/100 Series*



103 MINI-WINK NEON FLASHER. Random flash pattern. Interesting displays. 6 neon lamps. AC operated.
103 . . . . $3.00
103A (103 w/PCB) 4.65
103B (103 w/PCB,CASE) 6.90



110 ELECTRONIC WHOOPER SIREN. Powerful wailing sound. Dual oscillator circuit. Use with any alarm circuit. Battery not included.
110 . . . . $4.95
110A (110 w/PCB) 6.50
110B (110 w/PCB,CASE) 9.60

117 TUNABLE ELECTRONIC ORGAN. Tunable 7-note scale. Play sing-a-long favorites. Battery not included.
117 . . . . $7.55
117A (117 w/PCB) 9.50
117B (117 w/PCB,CASE) 12.60

120 SIREN/CODE OSCILLATOR. Loud, piercing alarm. Practice Morse code. Battery not included.
120 . . . . $4.20
120A (120 w/PCB) 5.55
120B (120 w/PCB,CASE) 8.65

104 VARIABLE STROBE LIGHT. Great for parties and photography. Variable flash rate. AC operated.
104 . . . . $10.60
104A (104 w/PCB) 14.85
104B (104 w/PCB,CASE) 20.35

126 PROGRAMMABLE DOORBELL. Adjustable rate and pitch for 15 musical notes. Play favorite tunes. 6 IC's. Uses existing transformer and switch.
126 . . . . $16.95
126A (126 w/PCB) 23.70
126B (126 w/PCB,CASE) 29.20

502 POWER SUPPLY. Switch from 6 to 9V DC. 100mA output. Filtered. Manual. Stepdown transformer. Insulated test clips.

$6.95 Complete

540 BINARY CLOCK. Handcraft tomorrow's timepiece today. Watch constantly changing patterns of LED's as they display Binary Time. This unique clock project enhances the learning of Digital Logic and the Binary Coding System, as well as offering a beautifully styled conversation piece.
10 TTL INTEGRATED CIRCUITS • VOLTAGE REGULATOR • MANUAL TEACHES BINARY SYSTEM • FAST, SLOW AND HOLD CONTROLS • 115VAC 50 or 60Hz.

$39.95 Complete

523 STROBE LITE. Create flashing light effects. Ideal for creating kaleidoscope effects for photography. Long life flash tube. PCB. Manual. Variable flash control. On-off switch. Silicon diodes. 117VAC 50-60 Hz.

$22.95 Complete

536 8-TRANSISTOR AM RADIO. Experience jewel-like clarity in sound. The best superheterodyne kit circuit available. SEPARATE LOCAL OSCILLATOR for high sensitivity and excellent selectivity. Unique IF Transformer mounting system. Manual. 9V battery required (not included).

$16.45 Complete

504 TRANSISTOR AMPLIFIER. 4 Transistors. Push-Pull output. Variable volume control. Requires one 9V battery (not included). PCB. Manual. 3 transformer stages for maximum gain. Power output 360mW. Can be operated with any 3.2 – 8 ohm speaker.

$6.95 Complete

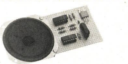
510 FIVE TUBE RADIO. Rediscover TUBES. This fun antique circuit offers high selectivity and sensitivity. 2 IF Transformers. Hi-Q Ferrite antenna. Manual. Superheterodyne circuit. Large PM speaker. For 110-120 VAC or DC.

$34.95 Complete

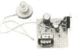
401 TACHOMETER. Know exactly when to shift. This fabulous Tach, with a range from 0-8 grand, will mount anywhere — dash, steering column, boat, motorcycle frame, etc. 250° wide sweep scale. Reading accuracy within 2% of full scale. PCB. Manual. Illuminated dial. For all cylinder engines.

$27.95 Complete

*Perforated Boards **NOT INCLUDED** w/100 Series*

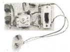


124 WARBLING SIREN. Two-tone oscillating siren. Loud and penetrating, 2 IC's. For automobile or other 12 volt systems.
124 . . . . $5.65
124A (124 w/PCB) 7.10
124B (124 w/PCB,CASE) 10.20

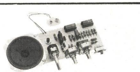


105 FISH CALLER. Clicking sound imitates distressed fish. Adjustable speed. Battery not included.
105 . . . . $3.15
105A (105 w/PCB) 4.30
105B (105 w/PCB,CASE) 5.80

107 COLOR ORGAN CONTROL — 3 CHANNEL. Over 200W per channel. Separate sensitivity control. Hi-mid-lo frequency response. AC operated.
107 . . . . $9.20
107A (107 w/PCB) 11.85
107B (107 w/PCB,CASE) 14.95



118 TV SCRAMBLER. Tunable to all VHF stations. 30 foot range. Battery not included.
118 . . . . $1.95
118A (118 w/PCB) 2.90
118B (118 w/PCB,CASE) 4.40



122 COMPUTER SOUND EFFECTS GENERATOR. Produces weird, spacey sounds. 4 IC's. Control tone, rate and blip or glide. Battery not included.
122 . . . . $14.95
122A (122 w/PCB) 19.40
122B (122 w/PCB,CASE) 22.75

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THE FIRST MEMORY SPECIAL YOU WON'T FORGET

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PRESCALER - 250 MHZ
complete $\$23^{95}$
PRESCALER - 650 MHZ
complete $\$49^{95}$
11C90 - PRESCALER CHIP 650 mc $\$19^{95}$

OPTO ISOLATORS

1. MCT2 $ .79
2. MOC1000 $ .89
3. 4N-26 $ .95
4. CL1422

CLAIREX PHOTO MODULE (USE AS VOLTAGE VARIABLE RESISTOR—40 MEG OHM TO 40 OHM—MILLION TO ONE RATIO—OR USE AS VERY HIGH VOLTAGE OPTO ISOLATOR) $\$1^{49}$

SOLID STATE RELAY
• 400 V at 3 AMPS • TTL COMPATIBLE • MICRO REED ACTUATED TO MINIMIZE CHANCES OF AC POWER SPILLOVER INTO LOGIC CIRCUITS $\$3^{95}$

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S11020H -20 Watt	$10.50
S11130H -30 Watt	$12.50
STK-50 -50 Watt	$18.95

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STK433-5 Watts per channel	$6.95
STK435-7 Watts per channel	$9.95
STK437-10 Watts per channel	$11.95
STK439-15 Watts per channel	$13.95
STK441-20 Watts per channel	$16.95

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8080A	5.95
8212	3.75
8214	8.95
8216	3.50
8224	4.80
8226	4.75
8228	7.25
8238	8.25
8251	9.45
8253	21.50
8255	10.75
8257	20.50
8259	20.50

Z-80 SYSTEM

3880	22.50
3881	12.50
3882	12.50
3883	49.00
3884	73.00

6800 SYSTEM

6800	16.95
6810	7.20
6820	7.95
6821	8.50
6850	8.95
6852	11.95
6860	9.95
6862	13.75

6500 SYSTEM

6502	14.95
6520	12.75
6522	12.50
6530	17.50

9900 SYSTEM

9900	66.00
9901	23.75
9902	19.50
9980	54.00
9981	54.00

1800 SYSTEM

1802	24.00
1821	19.50
1822	20.25
1824	13.50
1852	13.75
1856	11.75
1857	11.76
1861	20.00

CPU's

2650	19.95
2901	19.95
PACE	19.00
SC/MP	14.95

CPU's cont.

8008	8.95
8035	19.95

RAM

7489	2.95
3101	3.95
8225	2.95
2101-1	2.95
2101-2	3.25
2101A-4	3.25
2102-2	1.50
2102L1	1.95
82S10	4.95
82S11	4.95
5101L-3	11.95
2107	3.95
TMS4060	3.95
UPD411	3.95
4200A	9.95
2114 200ns	13.50
2114 450ns	10.95
2114 650ns	6.25
4116 200ns	18.50
4116 300ns	17.50
4116 450ns	13.50

PROMS

8223	2.95
82S23	3.75
82S126	5.95
82S129	6.95
82S131	7.25
6306-1	6.95
93427	5.95
D3604	11.95
2616	50.00
1702A	4.95
2708	12.95
2716-5V	46.95

CHARACTER GENERATORS

2513 UC	7.95
2513 LC	7.95
2516	7.95
5240	7.95
MM6571A	9.95

KEYBOARD ENCODER

AY5-2376	14.95

UARTS

AY5-1012	8.95
AY5-1013	8.95
TR-1602	9.95
TMS6011	8.95

FIFO's

3341	7.95
1502E	10.95

PROG. LOGIC ARRAYS

82S100	11.95
82S101	11.95

SHIFT REGISTERS

C1402A	1.95
MM1403AH	1.95
MM5006AH	2.95
MM5060	3.95

CLOCK CHIPS

MM5311	7.95
MM5312	4.95
MM5313	7.95
MM5314	4.95
MM5315	7.95
MM5316	4.50
MM5375	5.95
TMS3834	6.95
CT7001	6.50

CALCULATOR CHIPS

MM5725	1.95
MM5736	1.95
MM5738	1.95
MM5739	1.95
MCS2521	1.95

INTERFACE CHIPS

DS0026	3.25
DS3608	3.85
DM8093	.95
DM8094	.95
DM8095	.95
DM8096	.95
DM8097	.95
DM8098	.95
DM8131	3.25
DM8202	1.45
DM8233	1.10
DM8234	1.10
DM8241	.45
DM8242	.45
DM8250	.90
DM8251	.90
DM8266	1.35
DM8267	1.35
DM8271	1.35
DM8544	1.30
DM8831	2.95
DM8833	2.60
DM8835	2.60
DM8836	4.75
DM8837	2.45
74273	2.60
74390	2.10
81LS95	1.95
81LS96	1.95
81LS97	1.95

S-100 MOTHER BOARD — 8 Slot Kit		69.00
S-100 32K STATIC MEMORY BOARD		
ALL BURNED IN	650ns	599.00
AND TESTED	450ns	735.00
ultra low power	200ns	875.00
S-100 EDGE CARD CONNECTORS		3.50
MAXI KEYBOARD — 53 Keys		19.95
MAXI KEYBOARD — 74 Keys		33.95
KEYPAD — 16 key	x-y matrixed	1.95
KEYPAD — 20 key	x-y matrixed	2.95
WIRE WRAP POSTS		
2 level 100/3.95	4 level	100/4.95
WIRE WRAP SOCKET PIN		100/7.95
TAPE READER — 12 level — includes both IR sources and pickups		29.00

MAKE YOUR OWN PAPER TAPE READER

1/10" SPACED PHOTO TRANSISTORS	10/9.50
REED RELAY — TTL compatible	1.89
SOLID STATE RELAY — micro reed actuated for total isolation	3.95
CRYSTAL FILTERS — 455 Kc miniature single section 1.95	dual section 2.95

PRECISION THERMISTORS

YSI- BEAD — 1%	5000 OHM	2.95
GLASS BEAD — 1%	15000 OHM	2.95
GLASS BEAD — 1%	200 OHM	2.95
CYLINDRICAL — .01%		3.95
POWER THERMISTOR — positive temperature coefficient 20-2500 OHM		2.95

D/A CONVERTER — NE5008 (8 bit)	7.95
D/A CONVERTER — DAC-01-SH (6 bit)	6.95
PHOTO DIODE — super fast 0.5ns	3.95
IR DETECTOR — super sensitive	4.95

READ OUTS — MULTI DIGIT
LCD-3-1/2 dig. .4"-4.95 3-1/2 dig. .3" 1.95
LED .17"-3 dig. 1.25 — 6 dig. 3.95 — 8 dig. 4.95

PHOTO DEVICES—DIODES, XSTR's, DARLINGTONS

2N5771 - 1.25	FPT100A - .79	MD1 - 1.95
H-38 - 3.25	MRD-250 - 1.95	LASCR - 1.95

HIGH VOLTAGE TRANSISTORS

2SC1358	100W-	1400V-5A	TO-3	7.95
BUY69B	110W-	800V-10A	TO-3	5.95
W905	100W-	500V-5A	Plastic	4.95
362-4	20W-	500V-1A	Plastic	2.25
338-7	20W-	350V-1A	Plastic	1.50

HIGH VOLTAGE DIODES

UNMARKED	1500V at 1 AMP	10/1.99
EG 250	2500V at .35 AMP	.95
HV60EL	6000V at 25 ma	1.95
SUBMINIATURE	20,000V at 100 ma	2.95

CARBIDE DRILL BITS AND ROUTER BITS
for P.C. board work — *MIXED SIZES*

OUR MIX — DRILLS	10/12.95	100/95.00
OUR MIX — ROUTERS	10/15.95	100/125.00

RADIO SHACK® TRS-80™ COMPUTER SERVICE AND MODIFICATION

BE FIRST TO TURN YOUR TRS-80 INTO A SUPER MACHINE

1. Keyboard and Video Mod
ADD RAM FOR LOWER CASE CHARACTERS AND CLEAN UP HORIZONTAL SMEAR (SEND YOUR TRS-80 MICROCOMPUTER ONLY)
PARTS AND LABOR $\$59^{00}$

2. Install 16K Memory
JUST SEND US YOUR TRS-80 MICROCOMPUTER AND WE DO THE REST.
16K OF MEMORY AND LABOR $\$189^{00}$

3. Level 2 plus 1 Mod
WE INSTALL *YOUR* LEVEL 2 SO YOU KEEP LEVEL 1 AND CAN USE IT BY JUST FLIPPING A SWITCH. (SEND LEVEL 2 WITH YOUR TRS-80)
$\$69^{00}$

4. Clock Mod
INCREASE YOUR PROCESSING SPEED BY 30%. WITH THIS OPTION YOU CAN SWITCH-SELECT BETWEEN THE FASTER 2.66MHZ CLOCK RATE AND 1.77MHZ.
INSTALLATION, PARTS AND LABOR $\$49^{00}$

5. Serial Printer Interface Mod
OPERATE CRYSTAL CONTROLLED TTY WITH LEVEL 1 OR 2. WE INSTALL SWITCH SELECTABLE BAUD RATES OF 75, 110, 137.5, 150, 300, 600, 1200, 2400, 4800, 9600 OR EXTERNAL. EIA RS232 AND CURRENT LOOP OUTPUT.
PARTS AND LABOR $\$119^{00}$

6. Mini Floppy Mod
YOU PROVIDE EXPANSION INTERFACE AND WE'LL INSTALL A PERTEC F D 200 MINI FLOPPY.
PARTS AND LABOR (PERTEC F D 200 MINI FLOPPY INCLUDED) FOR ONLY $\$425^{00}$

SPECIALS!! DO MORE THAN ONE MOD AND SAVE

MODS 1, 2, 3, 4 AND 5	$\$449^{00}$
MODS 1 AND 2	$\$234^{00}$
MODS 2 AND 3	$\$243^{00}$
16K MEMORY, PARTS AND INSTALLATION DATA	$\$159^{00}$

SEND TRS-80 KEYBOARD ONLY!!

RETURN SHIPPING:
FROM ENGLAND ADD $30.00 FOR AIR, $9.50 SURFACE MAIL
FROM JAPAN ADD $35.00 FOR AIR, $8.50 SURFACE MAIL

REPAIR— *WE WILL REPAIR ANY ORIGINAL TRS-80 MICROCOMPUTER OR ONE OF OUR MODIFICATIONS.*
ALL PARTS AND LABOR $\$69^{00}$

ALL WORK GUARANTEED UNCONDITIONALLY FOR 1 YEAR

NOTE: THIS IS AN INDEPENDENT SERVICE EFFORT NOT AFFILIATED WITH RADIO SHACK® OR TANDY CORPORATION.

TERMS FOR TRS-80 WORK: WE ACCEPT ONLY TRS-80 MICROCOMPUTERS! SHIP YOUR TRS-80 MICROCOMPUTER TO US, INSURED AND SUITABLY PACKAGED AND WE WILL RETURN SAME FREIGHT COLLECT. ALL FACTORY SEALS MUST BE INTACT. ANY UNIT WHOSE SEALS HAVE BEEN TAMPERED WITH WILL BE SHIPPED BACK IMMEDIATELY. MODS 1, 2, 4 AND 5 SEND TRS-80 MICROCOMPUTER ONLY. MOD 3 SEND YOUR TRS-80 MICROCOMPUTER AND LEVEL 2. MOD 6 SEND TRS-80 AND EXPANSION INTERFACE. **NORMAL TURN AROUND TIME IS UNDER 10 DAYS WITH CERTIFIED FUNDS**

F. REICHERT SALES

1110 E. GARVEY AVE.
W. COVINA, CA 91790
(213) 967-3846

- $20 MINIMUM ORDER
- FREE UPS DELIVERY ON U.S. ORDERS ONLY—OR BY SURFACE MAIL IF SPECIFIED.
- MONEY BACK GUARANTEE (MOS & LED DEVICES EXCLUDED)
- UNDER 8 HOUR PROCESSING ON MONEY ORDERS & CASHIER'S CHECK.
- SORRY! NO COD'S, PO'S OR CREDIT CARDS
- CALIF. RES. ADD 6% SALES TAX
- CANADA, PUERTO RICO & U.S. POSSESSIONS ADD U.S. $3.50. ALL OTHERS ADD U.S. $7.00.
- U.S. FUNDS ONLY.

DROP INTO ONE OF OUR LOCATIONS

LOS ANGELES
(213) 967-4611
LMN ELECTRONICS
1042 E. GARVEY AVE.
WEST COVINA, CA

PORTLAND
(503) 646-4044
WIZARD OF PARTS
8225 S.W. CIRRUS DR.
BEAVERTON, OREGON

DENVER
(303) 573-5214
ELECTRONIC LOLLIPOP
5643 N. BROADWAY, DENVER
(I-25 & 58th AVE.)

ALL ITEMS SUBJECT TO PRIOR SALE

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

CIRCLE 72 ON FREE INFORMATION CARD

FREQUENCY COUNTER KIT

Outstanding Performance

Incredible Price 89^{95}

CT-50

The CT-50 is a versatile and precision frequency counter which will measure frequencies to 60 mHz and up to 600 mHz with the CT-600 option. Large Scale Integration, CMOS circuitry and solid state display technology have enabled this counter to match performance found in units selling for over three times as much. Low power consumption (typically 300-400 ma) makes the CT-50 ideal for portable battery operation. Features of the CT-50 include: large 8 digit LED display, RF shielded all metal case, easy pushbutton operation, automatic decimal point, fully socketed IC chips and input protection to 50 volts to insure against accidental burnout or overload. And, the best feature of all is the easy assembly. Clear, step by step instructions guide you to a finished unit you can rely on.

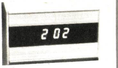
Order your today!

SPECIFICATIONS:

Frequency range: 6 Hz to 65 mHz, 600 mHz with CT-600
Resolution: 10 Hz @ 0.1 sec gate, 1 Hz @ 1 sec gate
Readout: 8 digit, 0.4" high LED, direct readout in mHz
Accuracy: adjustable to 0.5 ppm
Stability: 2.0 ppm over 10° to 40° C, temperature compensated
Input: BNC, 1 megohm/20 pf direct, 50 ohm with CT-60C
Overload: 50VAC maximum, all modes
Sensitivity: less than 25 mv to 65 mHz, 50-150 mv to 600 mHz
Power: 110 VAC 5 Watts or 12 VDC @ 400 ma
Size: 6" x 4" x 2", high quality aluminum case, 2 lbs
ICS: 13 units, all socketed

CT-50, 60 mHz counter kit	$89.95
CT-50WT, 60 mHz counter, wired and tested	159.95
CT-600, 600 mHz scaler option, add	29.95
CB-1, Color TV calibrator-stabilizer	$14.95
DP-1, DC probe, general purpose probe	12.95
HP-1, High impedance probe, non-loadir	15.95

CAR CLOCK



The UN-KIT, only 5 solder connections

Here's a super looking, rugged and accurate auto clock which is a snap to build and install. Clock movement is completely assembled—you only solder 3 wires and 2 switches, takes about 15 minutes! Display is bright green with automatic brightness control photocell—assures you of a highly readable display, day or night. Comes in a satin finish anodized aluminum case which can be attached 5 different ways using 2 sided tape. Choice of silver, black or gold case (specify).

DC-3 kit, 12 hour format	$22.95
DC-3 wired and tested	$29.95
110V AC adapter	$5.95

Under dash car clock

12/24 hour clock in a beautiful plastic case features: 6 jumbo RED LEDS, high accuracy (1 min/mo.), easy 3 wire hookup, display blanks with ignition, and super instructions. Optional dimmer automatically adjusts display to ambient light level.

DC-11 clock with mtg. bracket	$27.95
DM-1 dimmer adapter	2.50

PRESCALER

Extend the range of your counter to 600 mHz. Works with any counter. Includes 2 transistor pre-amp to give super sens, typically 20 mv at 150 mHz. Specify ÷ 10 or ÷ 100 ratio.

PS-1B, 600 mHz prescaler	$59.95
PS-1BK, 600 mHz prescaler kit	49.95

OP-AMP SPECIAL

741 mini dip	12/$2.00
B1-FET, mini dip, 741 type	10/$2.00

VIDEO TERMINAL

A completely self-contained, stand alone video terminal card. Requires only an ASCII keyboard and TV set to become a complete terminal unit. Two units available, common features are: single 5V supply, XTAL controlled sync and baud rates (to 9600), complete computer and keyboard control of cursor. Parity error control and display. Accepts and generates serial ASCII plus parallel keyboard input. The 3216 is 32 char. by 16 lines, 2 pages with memory dump feature. The 6416 is 64 char. by 16 lines, with scrolling, upper and lower case (optional) and has RS-232 and 20ma loop interfaces on board. Kits include sockets and complete documentation.

RE 3216, terminal card	$149.95
RE 6416, terminal card	189.95
Lower Case option, 6416 only	13.95
Power Supply Kit	14.95
Video/RF Modulator, VD-1	6.95
Assembled, tested units, add	60.00

CALENDAR ALARM CLOCK

The clock that's got it all; 6-.5" LEDs, 12/24 hour, snooze, 24 hour alarm, 4 year calendar, battery backup, and lots more. The super 7001 chip is used. Size: 5x4x2 inches.

Complete kit, less case (not available) DC-9	$34.95

30 Watt 2 mtr PWR AMP

Simple Class C power amp features 8 times power gain. 1 W in for 8 out, 2 in for 15 out, 4 W in for 30 out. Max. output of 35 W, incredible value, complete with all parts, less case and T-R relay.

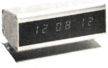
PA-1, 30 W pwr amp kit	$22.95
TR-1, RF sensed T-R relay kit	6.95

FM MINI MIKE KIT

A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality by means of its built in electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.

FM-3 kit	$12.95
FM-3 wired and tested	16.95

CLOCK KITS



our Best Seller your Best Deal

Try your hand at building the finest looking clock on the market. Its satin finish anodized aluminum case looks great anywhere, while six .4" LED digits provide a highly readable display. This is a complete kit, no extras needed, and it only takes 1-2 hours to assemble. Your choice of case colors: silver, gold, bronze, black, blue (specify).

Clock kit, 12/24 hour, DC-5	$22.95
Clock with 10 min. ID timer, 12/24 hour, DC-10	27.95
Alarm clock, 12 hour only, DC-8	24.95
12V DC car clock, DC-7	27.95

For wired and tested clocks add $10.00 to kit price.

Hard to find PARTS

LINEAR ICs		REGULATORS	
301	$ .35	78MG	$1.25
324	1.50	723	.50
380	1.25	309K	.85
380-8	.75	7805	.85
555	.45	78L05	.25
556	.85	7905	1.25
566	1.15	7812	.85
567	1.25	7912	1.25
1458	.50	7815	.85
3900	.50	**TTL ICs**	
CMOS ICs		74S00	.35
4011	.20	7447	.65
4013	.35	7475	.50
4046	1.85	7490	.50
4049	.40	74196TI	1.35
4518	1.25	**SPECIAL ICs**	
5369	1.75	11C90	13.50
TRANSISTORS		10116	1.25
2N3904 type	10/1.00	4511	2.00
2N3906 type	10/1.00	5314	2.95
NPN 30W Pwr	3/1.00	5375AB	2.95
PNP 30W Pwr	3/1.00	7001	6.50
2N3055	.60	4059 ÷ N	9.00
UJT 2N2646 type	3/2.00	7208	17.95
FET MPF102 type	3/2.00	**LEDs**	
UHF 2N5179 type	3/2.00	Jumbo red	8/1.00
MRF-238 RF	11.95	Jumbo green	6/1.00
SOCKETS		Jumbo yellow	6/1.00
8 pin	10/2.00	Mini red	8/1.00
14 pin	10/2.00	Micro red	8/1.00
16 pin	10/2.00	BiPolar	.75
24 pin	4/2.00	**FERRITE BEADS**	
28 pin	4/2.00	With info, specs	15/1.00
40 pin	3/2.00	6 hole balun	5/1.00

Ramsey's famous MINI-KITS

FM WIRELESS MIKE KIT

Transmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.

FM-1 kit **$2.95** FM-2 kit **$4.95**

COLOR ORGAN/MUSIC LIGHTS

See music come alive! 3 different lights flicker with music. One light for lows, one for the mid-range and one for the highs. Each channel individually adjustable, and drives up to 300W. Great for parties, band music, nite clubs and more.

Complete kit, ML-1 **$7.95**

LED BLINKY KIT

A great attention getter which alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights, anything! Runs on 3 to 15 volts.

Complete kit, BL-1 **$2.95**

VIDEO MODULATOR KIT

Converts any TV to video monitor. Super stable, tunable over ch. 4-6. Runs on 5-15V, accepts std. video signal. Best unit on the market!

Complete kit, VD-1 **$6.95**

TONE DECODER

A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone decoding, tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.

Complete kit, TD-1 **$5.95**

WHISPER LIGHT KIT

An interesting kit, small mike picks up sounds and converts them to light. The louder the sound the brighter the light. Completely self-contained, includes mike, runs on 110VAC, controls up to 300 watts.

Complete kit, WL-1 **$6.95**

SUPER SLEUTH

A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2 W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.

Complete kit, BN-9 **$5.95**

POWER SUPPLY KIT

Complete triple regulated power supply provides variable 6 to 18 volts at 200 ma and + 5V at 1 Amp. Excellent load regulation, good filtering and small size. Less transformers, requires 6.3V @ 1 A and 24 VCT.

Complete kit, PS-3LT **$6.95**

SIREN KIT

Produces upward and downward wail characteristic of a police siren. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.

Complete kit, SM-3 **$2.95**

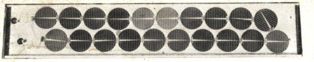
ramsey electronics

BOX 4072, ROCHESTER, N.Y. 14610

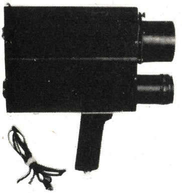
PHONE ORDERS CALL (716) 271-6487

TERMS: Satisfaction guaranteed or money refunded. COD, add $1.50. Minimum order, $6.00. Orders under $10.00, add $.75. Add 5% for postage, insurance, handling. Overseas, add 15%. NY residents, add 7% tax.

CIRCLE 45 ON FREE INFORMATION CARD



Solar cell panels, used, OK condition
20 cell panel, 2″ cells 6 volt ½ amp .... $ 75.00
36 cell panel, 12 volt ⅓ amp 100.00
24 cell panel, 8 volt .45 amp 85.00
10 half cell panel, 5 volt ¼ amp 50.00
5 cell panel, 2.5 volt ½ amp 40.00
Single 3.5 inch cell, 1 amp, .45 volt 8.50
Solar power kit, 3.5 inch cell, motor, propellor .. $ 10.25
ULTRASONIC room alarm, intrusion detection with full data for hookup 40.00



SEE IN THE DARK
IR viewer complete ready to operate. Guaranteed by the manufacturer. Portable, runs on lantern battery. New, see in total darkness. No shipments to Calif. Comes complete with built in IR source and adjustable focus lens.
SPL-21 $199.00

All items FOB Lynn, Mass. Send for free 64 page catalog jam packed with goodies.

Meshna Inc., PO Box 62, E. Lynn, Mass. 01904

CIRCLE 39 ON FREE INFORMATION CARD

WIRE WRAP

— PRECUT WIRE —

Why buy wire on rolls?

PRECUT & STRIPPED WIRE IS:

- **Fast** - No more cutting & stripping by hand
- **Reliable** - Good, clean, uniform strip
- **Economical** - Cheaper than using bulk wire

PRECUT WIRE	BULK WIRE
100 pcs of 3″ at $.82 = **3 1/4¢/ft.**	50 ft. roll at $1.99 = **4¢/ft.**
100 pcs of 6″ at $1.06 = **2¢/ft.**	100 ft. roll at 2.95 = **3¢/ft.**
Wire Kit 1 at $6.95 = **2 1/3¢/ft.**	

30 Kynar stripped 1″ on each end. Lengths are overall. Colors: Red, Blue, Green, Yellow, Black, Orange, White. Wire packaged in plastic bags. Add 25¢/length for tubes.

	100	500	1000	5000
2½ in.	.78	2.40	4.30/K	3.89/K
3 in.	.82	2.60	4.71/K	4.22/K
3½ in.	.86	2.80	5.12/K	4.55/K
4 in.	.90	3.00	5.52/K	4.88/K
4½ in.	.94	3.21	5.93/K	5.21/K
5 in.	.98	3.42	6.34/K	5.52/K
5½ in.	1.02	3.65	6.75/K	5.86/K
6 in.	1.06	3.85	7.16/K	6.19/K
6½ in.	1.15	4.05	7.57/K	6.52/K
7 in.	1.20	4.25	7.98/K	6.85/K
7½ in.	1.25	4.45	8.39/K	7.18/K
8 in.	1.29	4.65	8.80/K	7.53/K
8½ in.	1.32	4.85	9.21/K	7.84/K
9 in.	1.36	5.05	9.62/K	8.17/K
9½ in.	1.40	5.25	10.03/K	8.50/K
10 in.	1.45	5.51	10.44/K	8.83/K
Addl. in.	.10	.41	.82/K	.66/K

WIRE KITS

#1	$6.95	# 2	$19.95
250 3″	100 4″	250 2½″	250 4½″ / 250 6″
250 3½″	100 5″	500 3″	250 5″ / 100 6½″
100 4″	100 6″	500 3½″	100 5½″ / 100 7″
		500 4″	1 250 ft. roll bulk

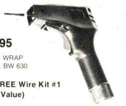
Choose One Color or Assortment

WIRE WRAP SOCKETS

	1-9	10-24	25-99	100-249	250-999	1K-5K
8 pin*	.35	.33	.31	.29	.25	.23
14 pin*	.35	.33	.31	.29	.28	.27
16 pin*	.37	.35	.33	.31	.30	.29
18 pin*	.60	.55	.45	.43	.40	.37
20 pin	.84	.78	.71	.63	.59	.54
22 pin*	.90	.85	.82	.78	.70	.60
24 pin	.91	.84	.78	.68	.64	.59
28 pin	.95	.89	.84	.80	.76	.74
40 pin	1.50	1.40	1.30	1.20	1.05	.90

Gold 3-Level Closed Entry Sockets
End & Side Stackable — All prices include gold
2-Level Sockets Available

WIRE WRAP TOOLS



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4007 –	.18	4022 –	.90	4055 –	1.25	74C86 –	.40
4009 –	.37	4023 –	.18	4066 –	.70	74C93 –	.75
4010 –	.37	4024 –	.75	4071 –	.18	74C151	1.40
4011 –	.18	4025 –	.18	4076 –	.97	74C160	1.05
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4015 –	.75	4030 –	.33	74C04 –	.24	74C193	1.20
4016 –	.29	4035 –	.97	74C08 –	.22	74C901	.48
4017 –	.90	4042 –	.65	74C10 –	.27	74C902	.48
4018 –	.90	4046 –	1.35	74C42 –	.85	74C914	1.70

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400	.09	.25	.50	1.40	6.50	9.50
600	.11	.30	.70	1.80	8.50	12.50
800	.15	.35	.90	2.30	10.50	16.50
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7403–	.13	7448–	.68	74155–	.58
7404–	.15	7450–	.15	74157–	.55
7405–	.13	7472–	.25	74161–	.55
7406–	.16	7473–	.28	74162–	.79
7407–	.20	7474–	.28	74163–	.55
7408–	.18	7475–	.45	74164–	.85
7409–	.18	7476–	.30	74165–	.95
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7411–	.18	7483–	.65	74173–	1.20
7412–	.13	7485–	.87	74174–	.95
7413–	.36	7486–	.28	74175–	.85
7414–	.60	7489–	1.25	74176–	.75
7416–	.22	7490–	.42	74177–	.75
7417–	.25	7491–	.58	74180–	.65
7420–	.13	7492–	.43	74181–	1.90
7425–	.25	7493–	.43	74190–	1.00
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7427–	.19	7495–	.65	74192–	.79
7430–	.13	7496–	.65	74193–	.79
7432–	.22	74107–	.28	74194–	.80
7437–	.21	74121–	.29	74195–	.50
7438–	.21	74122–	.38	74196–	.86
7440–	.13	74123–	.45	74279–	.55
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74LS03 –	.19	74LS139 –	.70
74LS04 –	.21	74LS151 –	.59
74LS05 –	.21	74LS153 –	.59
74LS08 –	.21	74LS155 –	.62
74LS09 –	.21	74LS156 –	.62
74LS10 –	.20	74LS157 –	.59
74LS11 –	.20	74LS160 –	.79
74LS13 –	.40	74LS161 –	.79
74LS14 –	.80	74LS162 –	.79
74LS15 –	.21	74LS163 –	.79
74LS20 –	.21	74LS168 –	.80
74LS21 –	.21	74LS169 –	.80
74LS22 –	.21	74LS170 –	1.40
74LS26 –	.29	74LS173 –	.95
74LS27 –	.25	74LS174 –	.72
74LS28 –	.26	74LS175 –	.75
74LS30 –	.21	74LS181 –	2.00
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74LS37 –	.28	74LS191 –	.88
74LS38 –	.28	74LS192 –	.88
74LS40 –	.21	74LS193 –	.88
74LS42 –	.60	74LS195 –	.50
74LS47 –	.73	74LS196 –	.75
74LS51 –	.25	74LS197 –	.75
74LS54 –	.25	74LS221 –	1.00
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74LS74 –	.34	74LS258 –	.68
74LS75 –	.50	74LS265 –	.25
74LS76 –	.35	74LS279 –	.50
74LS85 –	.75	74LS290 –	.60
74LS86 –	.35	74LS293 –	.58
74LS90 –	.50	74LS365 –	.49
74LS92 –	.50	74LS366 –	.49
74LS93 –	.50	74LS367 –	.49
74LS109 –	.35	74LS368 –	.49
74LS112 –	.35	74LS375 –	.60
74LS113 –	.35	74LS386 –	.35
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LM 311	– .75
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LM 339	– 1.10
LM 358	– .70
LM 370	– 1.15
LM 377	– 1.60
LM 380	– .95
LM 381	– 1.25
LM 382	– 1.25
LM 387	– 1.25
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LM 553	– 2.50
LM 555	– .39
LM 556	– .85
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PRV	TRIACS 1A	10A	25A	SCR'S 1.5A	6A	35A
100	.40	.70	1.30	.40	.50	1.20
200	.70	1.10	1.75	.60	.70	1.60
400	1.10	1.60	2.60	1.00	1.20	2.20
600	1.70	2.30	3.60		1.50	3.00

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